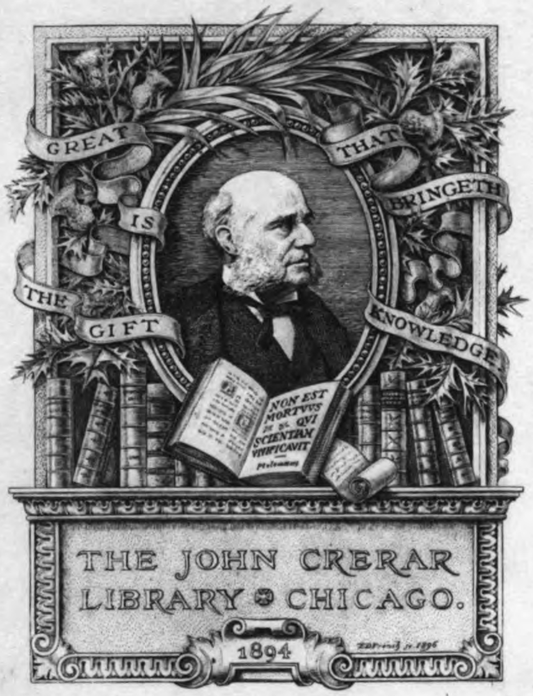
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THE YALE SCIENTIFIC MAGAZINE

VOL. I MAY, 1927 No. I

EAST PORTAL OF MOFFAT TUNNEL WHICH OPENS WAY TO NEW WEALTH OF NATURAL RESOURCES IN COLORADO ROCKIES (*Page* 7)

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL

PRICE FORTY CENTS

THE YALE SCIENTIFIC MAGAZINE

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1902 1927

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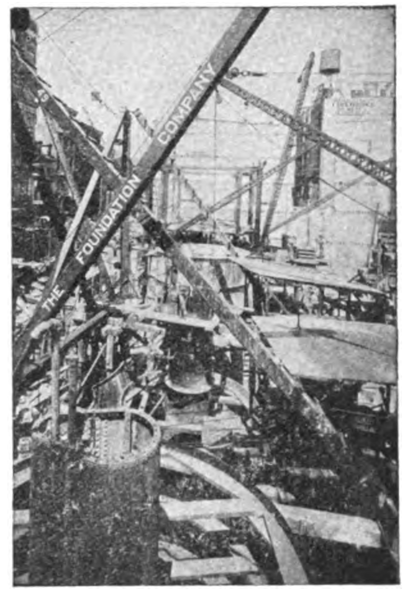

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DURING the first decade of this quarter century the skyline of New York began to take new form resting on the secure foundations constructed by this organization; then many owners, in other localities, noting the manner of its building, awarded to The Foundation Company contracts for complete construction, so that now the building of superstructures forms a great part of its work.

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Hydro-Electric Developments
Power Houses
Highways
River and Harbor Developments
Bridges and Bridge Piers
Mine Shafts and Tunnels

BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES

A LETTER FROM THE DEAN

YALE UNIVERSITY
SHEFFIELD SCIENTIFIC SCHOOL

OFFICE OF THE DEAN

NEW HAVEN, CONNECTICUT

May 3, 1927.

To the Editors,
The Yale Scientific Magazine:

I take this opportunity, on the occasion of the appearance of the first number of The Yale Scientific Magazine, to express my belief that the new enterprise, originated by your predecessors in last year's Senior class and now formally launched by you, will enjoy a long and useful life, that it will occupy an important place among the activities associated with the Scientific School and that it will reflect credit upon those of you who have shown such admirable initiative and ability in its founding. May your successors carry on with the same enthusiasm and success the work which you have begun.

Dedicated as it is to the purpose of promoting the interests of science and technology at Yale, it will, I am confident, serve as a medium through which the scientific work which is being done in the various departments of the University will be brought to the attention of a larger audience, receive a wider recognition, and awaken a greater interest in this important field of Yale's intellectual life.

Very sincerely yours,

Charles H. Warren.

Dean.

From The Editors

The Yale Scientific Magazine, while published primarily in the interest of science and engineering within the Sheffield Scientific School, will include accounts of the scientific accomplishments of Yale graduates. It will not cast its hat into the ring of campus controversies unless they shall lead to significant steps in the development of the school. By devoting our columns to news and not opinions, it is felt that we can be more interesting to our readers and of most service to the school.

We believe that in the hitherto unpublished research work of Yale's host of well-known scientists, both faculty and graduate, our readers will find sources of interest. We believe that Sheff.'s greatest need is a wider public appreciation of its work, which can be obtained only by a more complete knowledge of it.

* * *

The editors take this opportunity to thank the contributors for their generous co-operation, and the faculty for its patience in assisting us in compiling data for our first issue. We hope that you will keep us informed about articles of interest to our graduate and undergraduate subscribers.

* * *

In the late pages of this magazine will be found a section conducted by the Yale Engineering Association, which has subscribed for its entire membership, comprising the leading group of Yale graduates engaged in engineering pursuits. Since the editors of The Yale Scientific Magazine are in no way responsible for the contents of this department, all comments on it should be sent direct to the Yale Engineering Association.

* * *

We urge suggestions as to how this magazine can better fulfill its present program and how it may extend its activities and scope. Communications of interest to our readers will be published.

* * *

This, our first issue, reaches 1,400 graduate subscribers and 500 undergraduates, which is nearly 75% of the enrollment of the school.

America's Longest Tunnel Nearly Finished

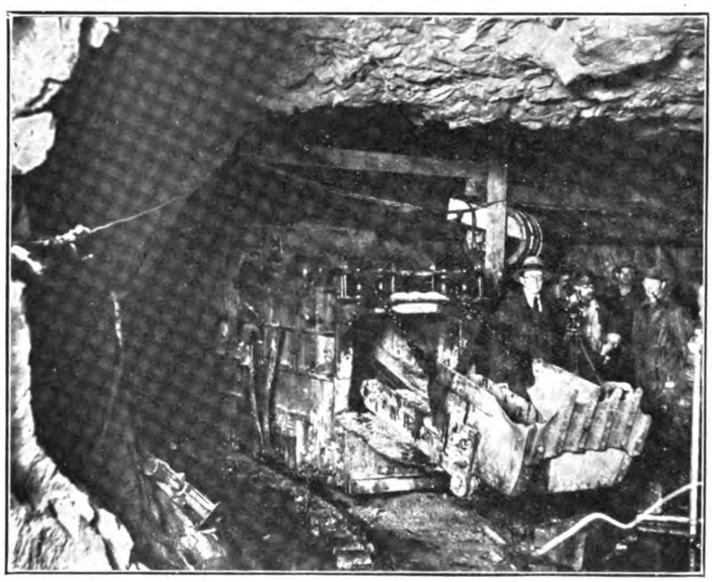
Six Mile Moffat Tunnel Through Solid Rock Will Give Outlet to Extensive Natural Resources in Colorado Rockies

By C. A. Betts, 1911

As the construction of the Moffat Tunnel swings into the final stages following the holing through of the Water Tunnel on February 18, when President Coolidge fired the final round by telegraph, the work is attracting widespread attention throughout the nation and is focusing interest on Colorado and her resources.

The longest railroad tunnel in America, the sixth longest in the world, the Moffat Tunnel is being driven through the Continental Divide at elevation 9,100 feet above sea level, fifty miles west of Denver, by a District of the State of Colorado known as The Moffat Tunnel Improvement District which was authorized by the Legislature to carry out the project and to administer it when finished. Financing is accomplished by issuing bonds guaranteed by the property within the District, with the intention of ultimately retiring the investment out of revenue from rentals. The Denver & Salt Lake Railway Company has contracted for the railroad tunnel and will pay about two-thirds of the total costs. The remaining third can be paid by the District in return for the benefits received by water rentals or other uses.

The purpose of this public enterprise is to provide adequate transportation for the rich Northwestern section of Colorado where vast resources consisting of coal, oil, oil-shale, minerals, live stock, agricultural products and timber await release. By the construction of the forty-mile Dotsero Cutoff connecting Orestod on the Denver & Salt Lake Railroad and Dotsero on the Denver & Rio Grande Western Railroad, the rail distance between Denver and Salt Lake City will be reduced 173 miles and Denver will be placed on a through Trans-Continental route. Eventually, if the line between Craig, Colo., and Salt Lake City is constructed, the wealth of the Uintah Basin in Utah, with its gilsonite, coal, and farm products, will be added to the volume of traffic.



Single Track Railroad Tunnel Through Solid Rock.

In the twelve counties of Colorado that will be benefitted by the outlet afforded by the Moffat Tunnel, are over four and a half million acres of public lands, an area larger than the State of Connecticut. About 118,000 acres tributary to the Moffat Railroad are irrigated, 140,000 acres dray-farmed, and 700,000 acres used for grazing. Agricultural products from Middle and North Parks include head lettuce, peas and other special high altitude crops in addition to alfalfa, wheat, and potatoes. The lettuce is shipped as far as New York and demands top prices. There are large areas which have reached the limit of their development until railroad service is available to enable the producers to market their products.

It is estimated that by irrigation development about 130,000 acres more may be watered from the White, Yampa, and Colorado Rivers, and by re-use of water brought from the Western Slope to Denver through the water tunnel, upwards of about 100,000 acres of productive land may be added to the wealth of the territory adjacent to Denver. The future value of 100,000 acre feet of additional water supply to Denver can scarcely be estimated at this time, as the Western Slope supply represents the last line of defense in obtaining new large supplies.

Approximately 2,000,000,000 feet of merchantable timber, including lodgepole pine, spruce, and fir, are estimated by the United States Forest Service to be available beyond the tunnel and are being so administered that the future supplies will be preserved.

The mineral wealth of Northwestern Colorado consists of deposits of iron ore, zinc, lead, copper, molybdenum, uranium, vanadium, tungsten, and some gold and silver, largely undeveloped because the low grades which predominate require railroad transportation.

Of the oil-shale deposits in Colorado, which, it is estimated, contain as much oil as has been produced to date by all the wells in the United States combined, a large part are in Northwestern Colorado, awaiting the time when their production will be demanded by an increased price in oil, or by more economical distillation.

The oil production from the Moffat field, two years after its discovery, exceeds 3,000 barrels per day. Prospecting for other structures is being actively carried on and points to new discoveries.

It has been estimated by Prof. R. D. George, State Geologist, that there remains enough coal in Northwestern Colorado to supply the United States for 1,500 years, and that that much more is to be found over the Utah line in the Green River Uintah Basin. The Colorado fields include the Yampa, with an estimated tonnage of 39,000,000,000. The grades of coal range from bituminous to anthracite.

The Moffat Tunnel will be six miles long, rising on a grade of 3/10 of 1% from an elevation of 9,200 feet at East Portal to an apex near the center and thence descending on 8/10 and 9/10% grades to the West Portal, elevation, 9,085. This will eliminate the 30 miles of 4% grade over Rollins Pass at Corona, which has been the highest standard gauge railroad pass in the

world, elevation 11,660 ft., and has been very difficult to maintain because of the snow hazards at that elevation. Ten thousand eight hundred degrees of curvature will be abandoned between East and West Portals, leaving the ruling grade of the Denver & Salt Lake Railway 2% compensated and the maximum elevation on the road 9,240 ft.

The tunnel consists of a 16′ x 24′ single track, standard gauge, railroad tunnel driven parallel with and 75 ft. to the north of an 8′ x 9′ water tunnel with which it is connected at 1,500 feet intervals by 8′ x 8′ crosscuts. The smaller bore has been of great assistance as a service tunnel in caring for transportation, wiring, piping and ventilation, leaving the enlargement operations of the railroad tunnel free of such interference.

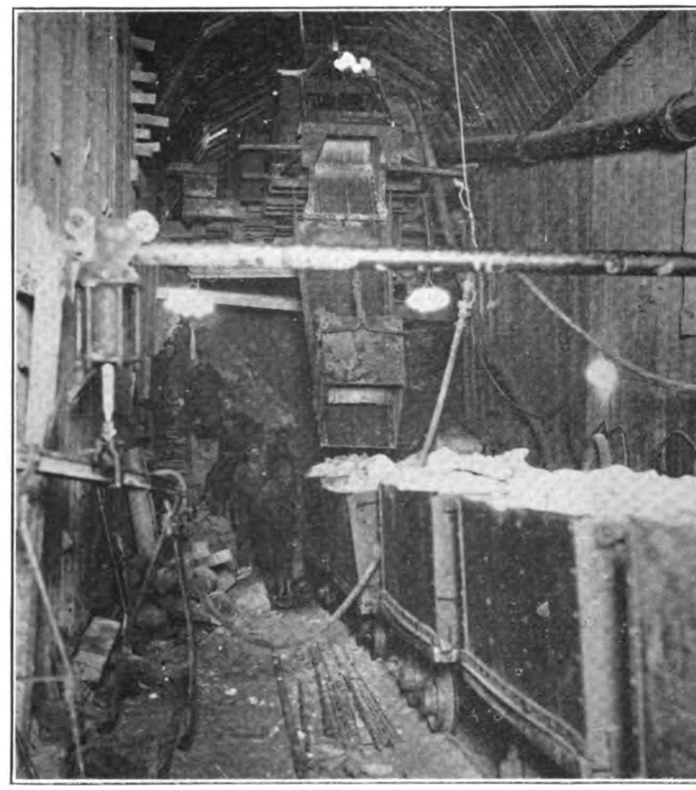
Natural conditions imposed an unusual variety of problems on the builders of the Moffat Tunnel and have taxed their resources on many occasions. Soft ground, flows of water, and unusual length of piping and transportation have added to the ordinary difficulties of tunnel driving, while the severe weather conditions, due to high altitude, have added to the difficulties of surveying the line for the tunnel.

On one occasion an inflow of 1,800 gallons per minute from Crater Lake nearly drained that lake into the tunnel before the seams through which the water entered were clogged by silt. In March, 1926, an inflow of 3,000 gallons per minute from Ranch Creek drainage basin on the western slope flooded the east headings which had passed the apex and were advancing down grade toward West Portal. The 1,200 gallons per minute still flowing in from this source is being handled by pumps and gutters.

Speed has been one of the main objectives in driving the tunnel. To this end labor-saving devices have been developed on the job and many new tunnel schemes have been successfully adopted. An airlift switcher, which picks up a muck car, swings it clear of the track and again deposits it on the rails when needed, was developed at East Portal, as was also a drill carriage mounting four drills and running on a 24-inch gauge track from one heading to another as the crews alternated.

Lewis Traveling Cantilever Girder supporting Roof while bench is being excavated and posts set. Note conveyor for handling heading muck into two-yard cars and air hoist switcher in the foreground.

The use of the twin heading method of driving by alternating crews between the water tunnel and main heading was a new departure in methods of attack, and resulted in a month's progress of 1,583 ft., by three crews working 8 hours a shift, and has given as high as 60 ft. of progress in one day. By having the drilling crew shoot an 8-ft. round in the water tunnel, for instance, while the mucking crew cleaned up the railroad heading and then reversing the crews, it was possible to complete a round in each heading in an 8-hour shift, with no interference between the crews. This was only practical in hard ground.



Survey Crew and Conway Electric Mucker at Crosscut Thirteen from which final round in water tunnel was shot. The author is on the left.

Enlargement to full size by radial ring drilling followed the heading operation in the solid granite sections of the bore.

In the soft material, which was encountered for three miles in from West Portal, it was necessary to drive top headings instead of center headings and to employ every known timbering devise to hold the ground as the pressure increased in some instances to over 4 tons per sq. ft. after exposure to the air.

The Lewis Travelling Girder (Fig. 1) was developed on the Moffat Tunnel to handle the enlargement of the railroad tunnel in this soft ground. A new departure in soft ground tunneling, this devise, which was designed to support the roof timbers and wall plates while the bench is being excavated and posts set to take the load, has successfully held the weight and speeded up progress. It is a contribution to tunnelling methods that will be of value in soft ground tunnels of large size and can be used for either heading and bench or pioneer tunnel operations.

Four Lewis girders have been put in use in the lined sections of the Moffat Tunnel, and their effectiveness has been tested through soft, running ground of slickensided gneiss as well as through blocky granite with water seams. On one occasion girder number one caught a cavein and probably saved the lives of many laborers working on the bench beneath.

Two plate girders 42 inches deep by 65 feet long, spaced 6 feet apart, with rigid cross braces of structural angles, constitute the backbone of the machine. The cross arms extending at right angles to the center line of the girder and supported below it by steel stirrups, can be moved out under the wall plates and jacked tightly up against them, using 15-ton jacks. The girder is kept from being overbalanced by crossarms and jacks at the

(*Continued on page 45*)

Discharge of Electricity in Rarefied Gases

Actual Behavior of Discharges in Various Gases Observed Under All Pressures. Striae of Hydrogen Act Singularly

By Prof. John Zeleny

Professor Zeleny has been carrying on research with various gases, obtaining interesting and instructive results. The practical application of such a study is ever increasing as the scope of science is ever widening. Professor Zeleny was formerly head of the Physics Department at the University of Minnesota, Until 1915

ELECTRICAL discharges through rarified gases present forms so varied and so beautiful that they have fascinated many observers ever since they were discovered. Yet, after being the object of intensive study for more than fifty years, there is much about these discharges that is not understood. It is my object in this article to describe briefly some investigations on this subject on which I am now engaged. The work done may be taken as an example of the fact that at times we begin a research by a study of some unusual occurrence that has attracted our attention and are led, step by step, to conclusions regarding matters seemingly far afield.

When an electrical discharge is passed through a rarified gas contained in a long glass tube the luminous aspects of the discharge over a limited range of pressures present the characteristics shown in Fig. 1. A negative glow, B, surrounds the negative electrode, A, but is separated from it by a dark region. The most remarkable feature is the positivec olumn, C, which consists of a number of equidistant, sharply defined patches of light, the so-called striae. Ordinarily the distance between these striae increases when the pressure of the gas is diminished, but an anomalous behavior in this regard was observed in hydrogen, in that, although with reduction of pressure the distance between the striae did at first increase, a maximum distance was reached and for still lower pressures the distance passed through a minimum value and then increased again down to the lowest pressure for which striations were visible.

Measurements, made with electrolytically prepared hydrogen freed from vapors from the pumps and pressure gauge by the interposition of a trap cooled with liquid air, gave the results shown by curve H in Fig. 2 for the relation between the pressure (abscissas) and the distance between striae (ordinates). The magnitude of the current, the diameter of the tube and some other circumstances influence the shape of the curve. A current of two milliamperes was here used and the tube's internal diameter was eleven mm. Similar measurements made under the same conditions with air, oxygen, argon, and helium gave the results represented by the other curves in Fig. 2, and it is seen that none of these show the same behavior as hydrogen. In each case the range covers all the pressures for which measureable striae were obtained.

Another puzzling observation made with hydrogen should be recorded. At a pressure of about two mm. a very slight reduction of pressure caused two or three of the striae nearest the cathode to break away one by one from the positive column and move up to and beyond the end of the cathode, where they united with the negative glow.

The question is pressing why in hydrogen the distance between the striae varies with pressure in the anomalous way that it does. It is now generally believed that the distance between striae is intimately related to the drop or potential required to give electrons a sufficient velocity to ionize the gas. When an ionizing collision occurs the electron loses its velocity and must traverse a certain distance before it can regain its ionizing power from the field. The periodic recurrence of places of maximum ionization accounts for the striae. An abrupt change of the distance between striae thus leads us to look for a change in the gas being ionized. It is well known that during a discharge some of the hydrogen is dissociated into atoms and as a working hypothesis let us imagine that the relative amount of atomic hydrogen present reaches a maximum at the pressure for which the striae are closest together, and that we then have to deal with ionization of atoms rather than of molecules of the gas. The energy required in the former case is only about 80 per cent of that in the latter. Some evidence on the energy acquired by the free electrons in the gas may be obtained by measuring the potential drop between adjacent striae. This drop is not a direct measure of the energy gained by the electrons because they lose some of their energy at ordinary non-ionizing impacts whose number depends upon the gas pressure.

For measuring the potential drop between striae, the form of tube shown in Fig. 1 was devised. Its main feature is a movable anode D, containing an iron cylinder, by aid of which it can be slid along the tube with an external magnet. The procedure is to measure the voltage across the tube necessary to produce a

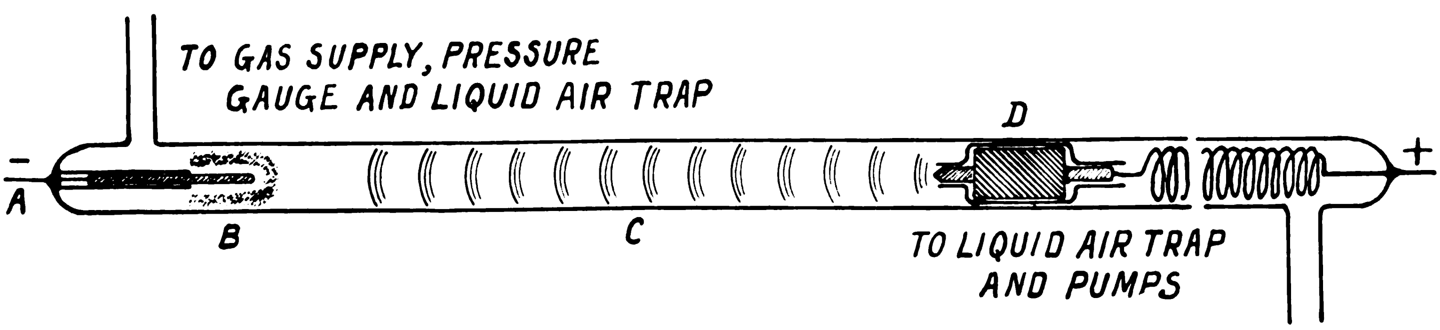


Fig. 1. Tube Used for Measuring the Voltage Drop between Striae.

given current when the anode is close to the cathode so that the positive column consists of a few striae only. Next a like measurement is made with the anode moved far back so that thirty to eighty new striae have been added to the column. The difference between the voltages required in the two cases divided by the number of additional striae in the second position of the anode gives the desired voltage drop between adjacent striae. The results, thus obtained with a current of six milliamperes flowing through the tube for the voltage drop between striae at different pressures, are shown graphically by Curve II in Fig. 3. It is seen that the voltage drop decreases regularly with diminishing pressures at least down to the pressure for which the striae have a minimum separation as indicated by Curve I, which shows for the current here used the variation of distance between striae with pressure of the gas.

Owing to the larger free paths of the electrons at the lower pressures it was to be expected in any case that the voltage drop between striae would decrease with decrease of pressure and support for the hypothesis, made above regarding the presence of hydrogen atoms, was to be found rather in a more or less abrupt change in Curve II on passing through the region of pressures corresponding to the minimum point of Curve I. The results obtained thus far fail to confirm the hypothesis made but a more conclusive answer can only be had after observations are available for still lower pressures. A curious fact has prevented thus far the getting of such observations. At these low pressures

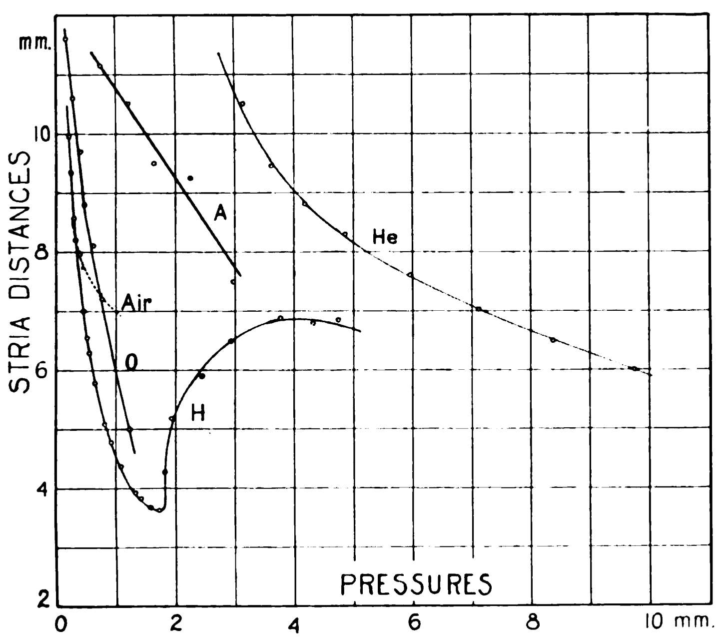


Fig. 2. Variation of Distance between Striae with Pressure in Air, Argon, Helium, Hydrogen and Oxygen. Current equals two milliamperes.

the passage of the discharge through the tube causes the pressure of the gas to decrease markedly in the time necessary for a single set of readings. Even a small change of pressure is fatal in this region because the voltage drop between the cathode and the first stria, which must be assumed to remain constant between the two sets of readings that must be taken to make a determination of the voltage drop between striae, changes very rapidly with pressure as is shown by Curve III of Fig. 3., the scale of ordinates for which is the one at the extreme right of the figure. The difficulty noted is now being surmounted by work still in progress in which a constant pressure is maintained in the tube by having a steady stream of gas flowing through it, new gas being let in at one end as fast as it is being pumped out at the other. It should be stated at this point that the hypothesis considered above is but one of the questions regarding which the experiments just described were designed to give evidence.

In conclusion something must be said regarding some spectroscopic testimony which has just been obtained. Different parts of the same stria in hydrogen often vary considerably in color, but in general the positive column as a whole has a light pinkish hue. The color is, however, decidedly bluish whenever the striae are in the state of minimum separation, even though

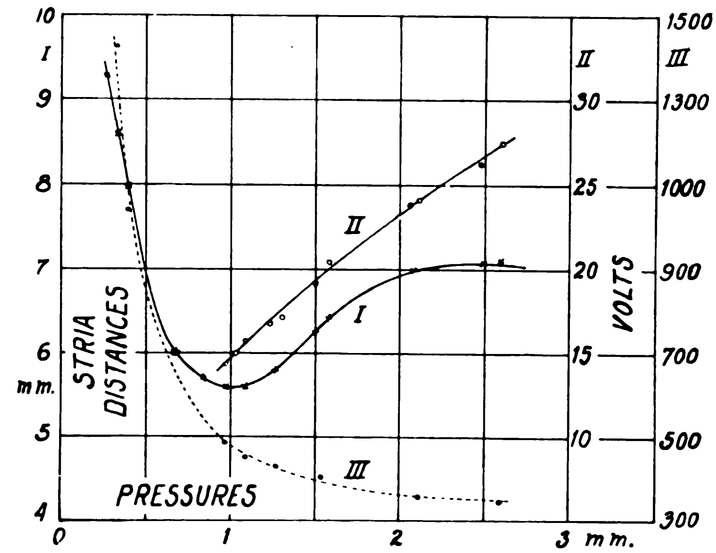


Fig. 3. Curve I. Variation of distance between striae with pressure in hydrogen for a current of six milliamperes. Curve II. Voltage drop between striae for different pressures. Curve III. Voltage drop between cathode and positive column for different pressures.

the total light intensity is approximately the same in the two cases. This fact in itself is conclusive evidence that different processes are at work in the gas in the two states. In hydrogen dried by the use of a liquid air trap, a spectroscopic examination shows the presence mainly of the secondary or molecular spectrum, although the atomic lines are also visible. The change in general color from pinkish to bluish which has been mentioned is not due to different spectral lines appearing in the two cases, but rather to certain of the lines having a greater intensity in one case and a different set being more pronounced in the other case.

Let us examine briefly the prevailing ideas regarding what is taking place in an atom or molecule during the process of radiation. A normal atom or molecule consists of a central positive portion with one or more electrons revolving about it. Each electron in its most stable position occupies a definite orbit near to the positive center or nucleus, but there are more distant quasi-stable orbits which it may occupy temporarily if knocked into one of them, for instance, by the impact of an extraneous electron. An atom or molecule having an electron so displaced is said to be in an "excited" state. Eventually the electron will return to its normal position and the excess energy it possessed in its outer orbit will be carried away by radiation, the frequency of which will be the greater the larger the difference between the energies of the electron in its two states. More energy is necessary therefore to bring an atom to an excited state which will result in blue light than is necessary to incite red light.

An atom may have an electron completely removed and is then said to be "ionized." Such an atom may capture an extraneous electron into one of its outer orbits, from which the electron may later return to its most stable position with emission of blue or red light, let us say, depending upon the orbit which it first

(*Continued on page 46*)

New Advances Made in Talking Movies

Movietone Equipment Developed by Yale Graduate Photographs Sound on Side of Film by Means of Electric Impulses Changed to Light Waves

By Theodore W. Case, 1911

THE conception of talking moving pictures is not by any means new. There have been various proposals along these lines dating back twenty or thirty years. In this country patents were taken out in 1880 by Fritts, over forty-seven years ago, proposing the photography of sound on film, and some years ago Edison actually tried commercially his talking pictures, which consisted in synchronizing disc recording with the moving picture machine. The reason that these older systems failed was because the necessary tools for accomplishing the results desired were not then available.

From the first there seemed to be two outstanding methods which promised the best results: 1. disc recording synchronized with the moving picture, and 2. actual photography of the sound on the same film with the picture. Movietone is a system based on the photography of the sound on the same film with the picture.

The author first carried on experiments at Yale University in 1911, with the view of finding out the possibilities of photographing sound on film and reproducing it, and found at that time that the necessary tools were even then not available. Since that time research on the development of the necessary tools for accomplishing the results desired has progressed to such an extent that it is now perfectly practical to photograph sound on a film and reproduce it.

In Movietone, the process consists of the sound being picked up by a high quality microphone, which changes the sound waves into electrical impulses. These electrical impulses are amplified and impressed on a specially designed type of gas discharge glow light, which is called the Aeo light. This Aeo light is inserted in the rear of a specially constructed motion picture camera so that the light, as it varies in intensity, due to the electrical impulses impressed upon it, passes through a narrow slit approximately .008 inch wide by .1 inch long. This slit is so positioned that the light passing through it will fall on the side of the film between the sprocket holes and the picture, which has been cut down by the width of the slit. Needless to say, the sound is photographed on the film at a place in the camera where continuous motion prevails, which is some five or six inches distant from the picture aperture, where there is intermittent motion. This takes us up to the actual photography of the sound on the same film as that upon which the picture is taken, in the same camera and at the same time. In this way synchronization is accomplished. The film is then developed in the ordinary manner and as many positives as desired may be made from the negative in a printer which has been redesigned so that both the sound record and the picture may be printed at any density desired.

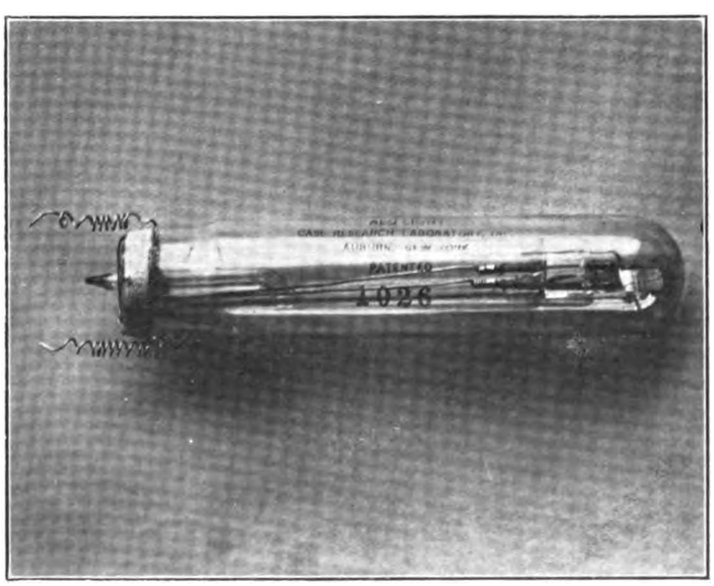


Fig. 1. The Aeo Tube, which permits the photography of sound on film and makes the new talking movies possible.

In reproduction, a standard projector is used with an added attachment, which consists of a small concentrated light source, a slit and a photo-electric cell. As the sound record passes the slit, the steady light coming through the slit is varied by the sound record, and the photo-electric cell transforms the light variations back into electrical pulses. These minute electrical pulses are then amplified and impressed on high quality loud speakers, which are placed back of a specially constructed screen which has a high light reflective power, but is transparent to sound.

It will be seen that the essential development for such a system consists of a very high quality microphone, high quality amplifiers, a gas discharge light which has the characteristics desired for faithful conversion of electrical pulses into light pulses, a specially constructed slit which is protected from dust, dirt, *et cetera*, getting into it, a camera which is so mechanically made that its motion is perfectly smooth, film which has as near straight line characteristics on exposure to light as possible, a photo-electric cell which is sensitive enough so that too much amplification is not necessary, and the best loud speakers obtainable.

In Movietone the high quality microphone, amplifier equipment and loud speakers used have been developed entirely by the Western Electric Company.

The camera which has been developed for Movietone is a modified Bell & Howell. The essential changes consisted in the replacement of the regular gear system by specially made gears so that the continuous motion of the film would be as smooth as it was possible to obtain. Of course, if there are any pulses in the mechanical movement of the film passing the slit these will become evident upon reproducing the sound. Considerable pulse may be present in speech reproduction and not be noticed, whereas in the reproduction of music it becomes evident immediately. There may be present either low frequency pulses or high frequency pulses. The latter become evident in such instruments as the violin, whereas the low frequency pulses are much more evident in the case of reproduction of the piano. It, therefore, becomes extremely important to have no mechanical pulses either in the

taking or reproducing part of the system. The main sprocket in the camera which pulls the film with continuous motion must be special in that it must run true within one-ten-thousandth of an inch. From this it will be seen that the mechanical work on the cameras must be of exceedingly high quality. A flywheel has also been added to this important sprocket, and the camera is run by an electric motor. At the rear of the camera a tube is inserted, at the interior end of which is placed the slit holder which is positioned continuous to the main sprocket over which

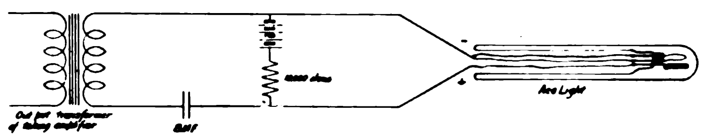


Fig. 2. Circuit for use of tube in light photography.

the film passes in continuous motion. When taking a sound picture the Aeo light is placed in this tube with the light source within approximately one-fourth of an inch of the slit.

The Aeo light is shown in Figure 1. It is one inch in diameter by five inches long. It consists of two electrodes, the negative of which is a very fine platinum wire loop which has been coated, first with calcium nitrate, then heated in air, which turns the calcium nitrate to calcium oxide and then a coating of barium nitrate is applied to the calcium oxide. This again is heated in air to form barium oxide. The positive electrode consists of a small nickel plate placed about one-quarter of an inch from the negative loop. By a special treatment the filamentary loop coated with the alkaline earth oxides is sensitized so that it is very active at normal temperatures in starting and maintaining a glow discharge without the polarizing effect noted in negative electrodes not so coated. Helium gas, pure, is introduced into this bulb, and the pressure so adjusted that the glow becomes an extremely concentrated light around the filamentary loop. This is the glow that is used in the photography of sound. The addition of the calcium and barium oxides to the filament accomplishes five definite results: 1. it allows the discharge to start at a lower voltage than if they were not present; 2. they allow a greater current to pass at a given applied potential; 3. much more

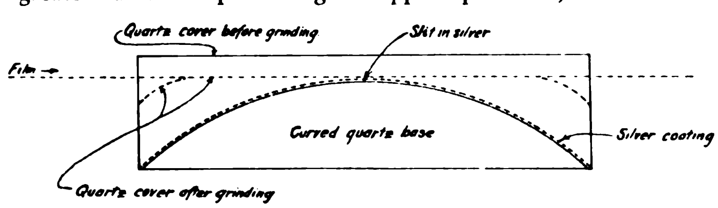


Fig. 3. Diagram of film passing over slit.

light is produced with a given wattage than if the oxides were not present; 4. polarizing effects are absent; 5. a greater intensity change of light is obtainable with a given current change. These lights may be used for about ten thousand feet of film, after which they become useless, due to cathodic sputtering. At first thought one might expect that almost any gas discharge light could be modulated electrically so that a satisfactory sound picture would result, but this is not so, and it is extremely difficult to produce a gas discharge light which has the characteristics desired. Figure 2. shows a simple circuit in which this light may be used for sound photography.

The photo-electric cell which has been developed and which is being used is a new one called the Barium cell.* The cell itself is a circular bulb approximately 2¼ inches in diameter, the interior of which is coated with a thin silver layer except for 1½-inch circular window opening for the admission of light. The anode of this cell consists of a circular platinum filament upon which has been coated a very thin layer of calcium oxide and on top of this a very thin layer of barium oxide. In manufacture the bulb is evacuated and baked at about 500° C. for several hours. Then by a special process the barium oxide coated filament is sensitized in such a way that upon subsequent heating of the filament to a very bright red an active photo-electric material is volatilized from the filament onto the silver which is the cathode of the photo-electric cell. The author believes that the active material is some form of suboxide of barium and not barium metal. The photo-electric current is read by a galvanometer during this process of coating, and when the maximum high vacuum action has been reached very pure hydrogen is introduced into the cell and a process of arcing is carried on for about three minutes, after which the high vacuum action is found to be approximately doubled. Then more hydrogen gas is passed into the cell, and it is sealed off at the pressure which gives the greatest action at a certain voltage, approximately 150 volts. These cells have been found to be very stable and will

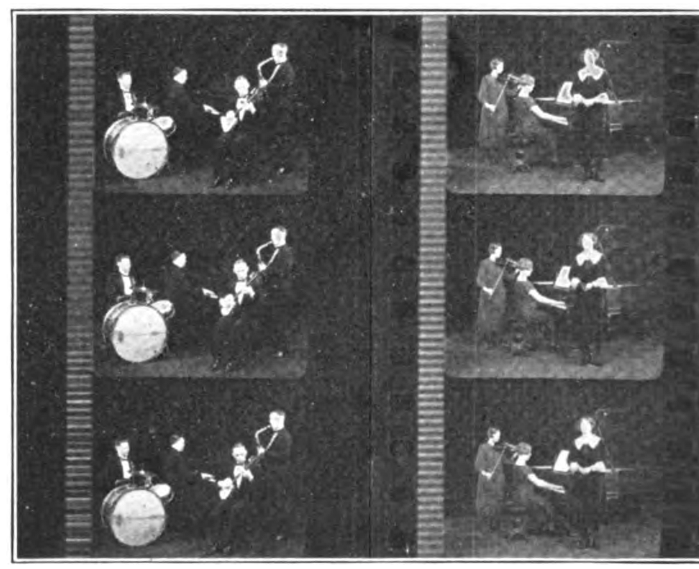


Fig. 4. Piece of film with sound recorded on side.

withstand much higher temperatures than the ordinary potassium cell. This is quite important, as the temperature is very high in the moving picture booth in the summer. In fact, sometimes the machines get so hot that it is impossible to hold one's hand on parts of the machine for any length of time.

The spectral sensitivity of the Barium cell runs throughout the visible spectrum. There is considerable sensitivity in the light red and yellow, and, of course, up through the green, blue, and violet. This makes it possible to reproduce colored or tinted films of the light reds and yellows with hardly any diminution of volume which is again quite important as a great many films are tinted amber and yellow. These cells can also stand more arcing than the ordinary potassium cell without bad effects, as hydrogen has been left in the cell.

It may be interesting also to describe the slit unit, as this, although simple, gave about as much trouble as anything that was developed. The requirements were an aperture approximately .0008 inch in width and .1 inch in length, which would let through as much light as possible. This aperture should be extremely close to the film in order to get as little dispersion as possible of the light after it passes through the slit. It was first found that to get the maximum amount of light the opaque walls of the slit should be as thin as possible and still be opaque, but the greatest problem was the protection of the aperture so that no dirt or dust, *et cetera*, could interfere with the trans-

* Physical Review, April, 1920.

mission of light through it. The problem was finally solved by making a quartz base approximately 1/4-inch square and 1/8-inch thick. On this a thin silver layer was deposited in which the aperture was ruled microscopically. Then a layer of quartz was cemented to this and ground down until the quartz remaining over the aperture was not much more than .005 inch in thickness. This protected the aperture and by rounding off the corners of the unit as shown, in Figure 3. so that, as the film passes over the unit, it will not catch the edge but will be only in contact directly over the aperture. These units are mounted in a holder so that they are interchangeable and quickly replaceable.

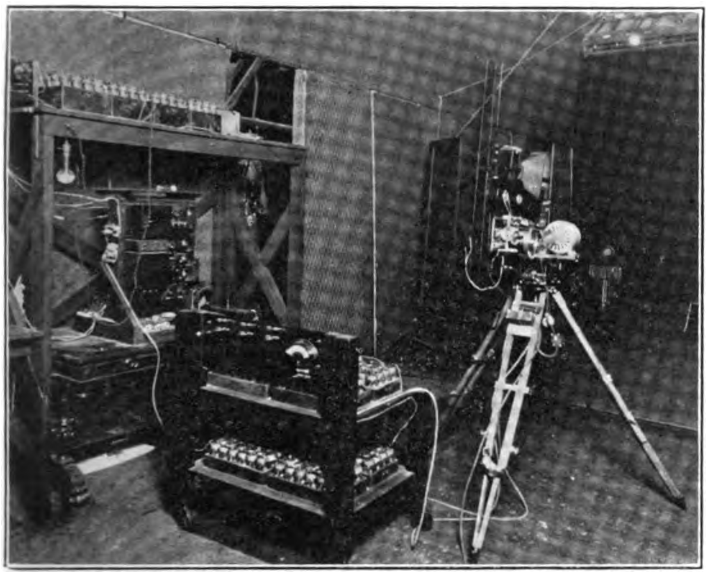


Fig. 5. Complete recording equipment.

In Figure 4. is shown a piece of the film with the sound record at the side between the sprocket holes and the picture.

It has been the intention in building up the Movietone system to make it as simple as possible and to use only low voltage and audio frequency current in exciting and modulating the taking light rather than high frequency current modulated by telephonic current, as has been proposed and tried, but which is more complicated and has certain disadvantages. Also, to put the sound record on the film in the same camera which takes the picture and keep away from mechanical methods of recording, which are subject to jar and necessitate the taking of the sound on a separate film. The resulting Movietone system is now so simple that portable sets have been built which may be placed in an automobile, and sound pictures may be taken almost anywhere. It is evident from this that the system is not limited to the studio.

Figure 5 shows the complete recording equipment, on the right being the special motion picture camera which records both the sound and the picture simultaneously.

Skin Grafting is an Undeveloped Science

Fundamentals of Modern Technic Long Known to Natives of India

By Dr. F. W. ROBERTS, '20S.

AMONG the Tilemaker caste of India long ago we find the first description of plastic work. This was done on the restoration of the nose by use of a pedicle flap from the forehead. Later we find attempts in Italy to repair the nose by flaps of skin from the arm. A wide expanse of time intervenes in which we have practically no advance in plastic work until the latter part of the last century, when the discovery of the transplantation of skin was made. Since that time many contributions have been made in the various departments of plastic surgery: operations for repair of hair lip and cleft palate, the development of the pedicle flap, the transplantation of cartilage and bone and a host of other minor procedures. The war had little influence on plastic work, although ample opportunity was afforded for the application of procedures already known. The field still remains relatively undeveloped and affords an opportunity for work and investigation. Plastic work does not necessarily restore beauty, but aims to repair malformations and defects which are serious handicaps to the individual in function and appearance. For example, the hair lip and cleft palate, if allowed to persist, not only is ugly in appearance, but incapacitates the individual in eating and speech. Scars from accidents and burns distort the features, with resulting contractures, restricting function and sometimes handicapping the victims tremendously. Plastic surgery attempts to repair these defects and malformations, making the patient better able to "carry on."

One of the most important phases of plastic surgery is the transplantation of skin. This may be accomplished by various methods in the vicinity of the area to be grafted or by transplantation from areas remote. In the latter instance this can be accomplished by four different methods.

(1) The Reverdin graft or Davis small deep graft.
(2) The Ollier-Thiersch graft.
(3) The Wolfe-Krause graft.
(4) The pedicled flap.

These methods will be briefly reviewed, giving a technic for each procedure.

The Reverdin Graft and Davis Small Deep Graft.

In 1869 Reverdin reported to the Societé imperial de chirurgie the successful transplantation of small pieces of epithelium* to a granulating wound† with resulting takes and epithelization of the wound. He described his grafts as being epithelial grafts, although he mentions the fact thati t was not always possible to cut grafts free from dermis‡ entirely. This method was shortly afterward taken up in Europe and America and is still used extensively. J. S. Davis of Baltimore has observed that grafts with dermis grow better. Consequently he has called these small deep grafts. The technic used in both types is the same.

The granulating surface must be prepared with great care for the reception of the grafts. It is important that the surface

* Epithelium—the epidermis, or outer layer of the skin, is composed of epithelium.

† Granulating wound—granulations are new connective tissue, pushed up from the bottom of the corium. Granulations cover all exposed structures.

‡ Dermis—the inner layer of the skin, contains the corium.

should be as clean as possible, with negative bacterial count and small red granulations. The amount of secretion should be reduced to a minimum. This can be best obtained by compresses of Dakin's solution. Twenty-four hours before grafting salt compresses are substituted, as Dakin solution has been found to impair the taking and growth of the graft.

A region is chosen as a source for the grafts, usually the thigh. The skin is cleaned with alcohol, ether, and potassium mercuric iodide. A straight needle is then grasped with a Halsted clamp and the point of the needle first inserted in the skin, raising it a little. With a knife drawn horizontal to the skin surface a circular cone of skin about one-quarter of an inch in diameter is excised. This is then planted on the prepared granulating surface. The grafts are then taken as closely as possible and planted within one-quarter of an inch of each other. When a sufficient number have been transferred a salt sponge is then placed over the grafts and gentle pressure exerted with the hand. This helps them to adhere to the granulating surface. They are then covered with perforated cellosilk, protective tissue or paraffin gauze, upon which sea sponges are strapped with adhesive to immobilize the grafts. The dressing is allowed to remain forty-eight hours, after which time they may be dressed with vaseline and dry gauze. The area from which the grafts are taken is covered with silver foil and dry gauze.

This type of graft is more commonly used than any other and particularly in large granulating surfaces caused by burns, wounds, etc. They can easily be transferred under novocain at the bedside.

About twelve hours after grafting, if the graft is taking, one can detect a slight pink blush. If it is not, the graft remains white and in time softens and sloughs away. By three to four days one can detect a small white halo about the healthy graft. This is the new epithelial edge which spreads quite rapidly and meets the advancing edges from other grafts until the whole area is finally epithelialized.

The Ollier-Thiersch Graft.

This type of graft consists of a thin film of epidermis and a portion of the dermis. Shortly after Reverdin in 1869 reported his success with small epidermal grafts Ollier of Lyon in 1872 described the use of large portions of skin, including the epidermis and parts of the dermis. In 1886 Thiersch reported that the healing of wounds of any size could be brought about more quickly by covering the defects with films of epidermis and part of the dermis. These were placed on fresh surfaces and granulation tissue was exercised. The method became widely used, and still is, particularly in covering large fresh surfaces. The most common instances in which the Ollier-Thiersch graft is used are in cases where skin edges cannot be approximated after radical resection of the breast, leaving an open fresh surface and in old chronic ulcers where the old granulations have been exercised and the underlying fresh surface cannot be covered.

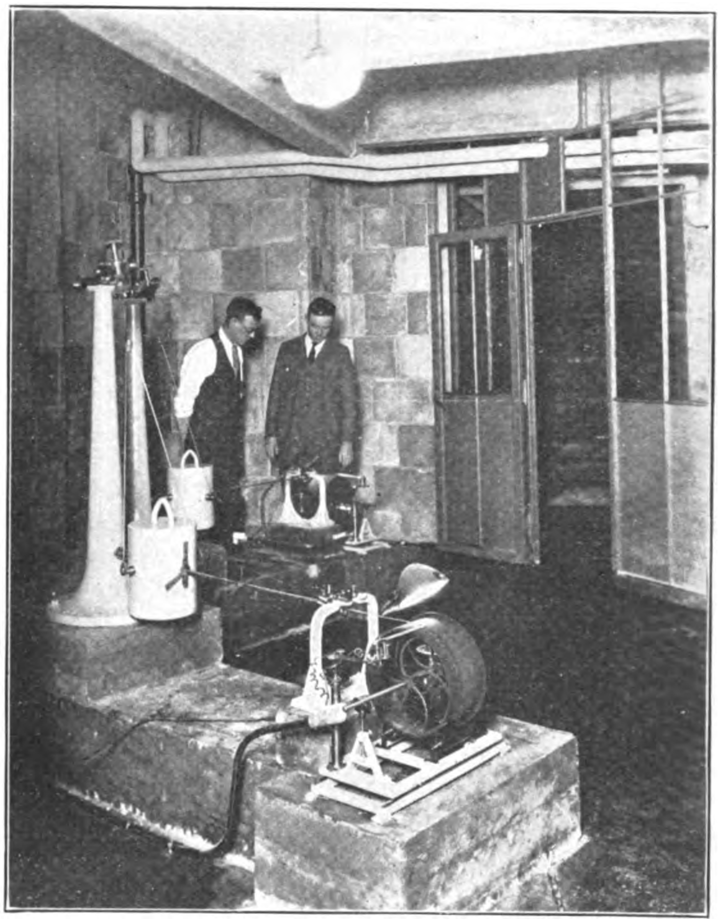
The method is quite simple. An area over the thigh or some other suitable area is cleaned with alcohol, ether and potassium mercuric iodide and with two small boards the skin is put under slight tension. With a Catlin knife, which has a long, thin sharp blade, a very thin film of epithelium is shaved off. The thickness of the graft is of some importance. The graft should be thin enough so that when laid on rubber protective moistened with saline it appears transparent. The size of the graft usually depends on one's skill in cutting it. It can be cut the length of the thigh and three or four inches across if desired. After the graft has been laid out flat on protective it is then placed over the fresh area and covered with silver foil and sea sponges. After eight days the dressing is removed and the graft has usually taken

(*Continued on page 41*)

SEISMOGRAPH INSTALLED IN MUSEUM

Peabody Now Houses Delicate Instrument That Records Earthquakes Worldwide

THE University has installed a very delicate seismograph in the Peabody Museum, which it operates in conjunction with the government Coast and Geodetic Survey Department. Under the arrangement, the daily records of the instrument are sent to Washington each month, where they are placed in the department's files. The most distant shock the instrument has recorded occurred in Japan on March 14th of this year. This is indicative of its sensitivity, as during the past year and a half it has missed only two tremors, both of which were very slight.



The Yale Seismograph Now Installed in Basement of Peabody Museum.

The present installation was made three years ago, when the Museum was completed. Although purchased from a German firm about twenty years ago, the seismograph had been unused for eight years, owing to the demolition of the old Museum, where it was housed when first obtained. Now it rests in the basement of the Peabody Museum on a foundation of bed rock which goes twenty-six inches below the surface. It consists essentially of two needles attached to lever arms at right angles to each other, and balanced so delicately that the slightest tremor will cause the arm to vibrate and make the needle trace the vibrations upon a drum of smoked paper. The central pedestal, the two arms, and the two drums may be seen in the accompanying photograph. The fulcrum on which each arm rests is a piece of spring steel .010 inches thick. The weight on the arm, seen near the pedestal, is suspended, as shown, by a piano wire .055 inches in diameter. This gives such a delicate balance that even a quick opening of the door of the glass walls surrounding the

(*Continued on page 46*)

Testing Determines Nature of Tire Slips

Sliding of Pneumatic and Solid Tires on Road Found to be Caused by Rubber "Creep" Which Results in Only Slight Loss of Power

By Prof. E. H. Lockwood, 88S.

This is One of the Tests Professor Lockwood Has Been Making on Various Phases of the Automobile Industry. He is at Present Engaged in Calculating for a Large Automobile Manufacturer the Actual Retarding Effect of Wind Resistance on Horse Power at Various Speeds Between Twenty and Fifty Miles Per Hour

THE average motorist, traveling over a rough road an feeling his rear wheels frequently bounding from the road, believes that considerable power is lost during these periods of slip between the tires and the road. That only minute losses occur may be concluded from theory confirmed by experimentation. The experiments described below have proved that tire slip is small and consists mostly of elastic crep of the rubber tires, which is found to produce slight abrasion and wear of the tread.

First, it may be pointed out that, if tire slip occurs, it may be in either direction. That is, the driving wheels will gain in angular displacement when power is applied to accelerate the vehicle and likewise will lose angular displacement when brakes are applied, both displacements being referred to a wheel which merely rolls without slip. Consequently it may happen that the positive and negative slip of the tires may exactly balance, yielding zero total displacement even with considerable actual slip in either direction. Car odometers are usually driven from the propeller shaft, hence share any disturbing effects of rear tire slip. Careful observations show that little or no variation in odometer readings have been observed between the same points, whatever the driving speed. This has often been taken to mean absence of slip, whereas it may mean simply the balance of ship in both directions.

It may also be pointed out that slip may occur in at least three different ways. The driving tire is always subject to a slow "creep" due to the elasticity of the rubber, by virtue of which the driving tires will slowly gain revolutions, while always remaining in contact with the road. This kind of slip is not found between rigid surfaces such as car wheel and rail, but is quite marked in the case of a leather belt driven by an iron pulley.

Another kind of slip refers to the momentary gain of displacement when the driving wheels rebound from the road, removing for an instant all resistance to rotation except that of inertia of the moving parts. The amount of this "rebound" slip will depend jointly on the irregularities of the road, car speed, and power exerted by the engine.

A final source of slip is the "skid" which results from loss of traction between tires and road, usually occurring only on wet or slippery pavements. This kind of slip will not be included in the present article, as it requires special treatment which has not yet been worked out.

It will be of interest to estimate the limiting values of tire "creep" from consideration of the elastic properties of the rubber tread. The tractive force at the tire circumference is continually acting to press the inner layers ahead of the outer layer in contact with the road. The effect of this stretching of the rubber is virtually to shorten the wheel radius, thus making more revolutions in covering a given distance. The amount of this shortening can be roughly estimated, since it cannot be greater than the thickness of the rubber tread, and probably is nearer one-half the tread thickness. Calling the thickness one-half inch, the reduction of tire radius can hardly be more than one-quarter inch in a total of sixteen inches, or about one and one-half per cent slip due to tire "creep."

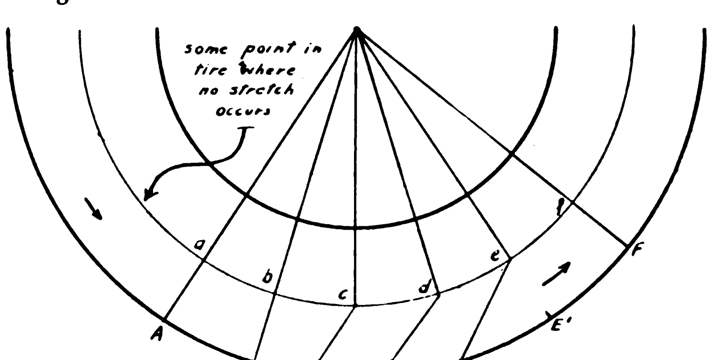
In a similar way "rebound" slip may be estimated from certain reasonable assumptions that may be made. The computation of rebound slip requires a mathematical analysis which will be readily understood by students of elementary mechanics. An outline of the mathematical theory follows for the benefit of those who desire to check the computations.

Assumed data for 3,500 pound car, equipped with a nominal 45 h.p. engine:

Engine torque, 30 h.p. at 1400 r.p.m.	$F = 110$ lb-ft.
Gear ratio, engine to rear wheels	$m = 1 : 5$
Moment of inertia, engine and drive	$I_1 = 45$ lb-ft.^{2}
Moment of inertia, wheel system	$I_2 = 100$ lb.-ft.^{2}
Car speed, miles per hr.	$S = 30$

It will be assumed that the wheels are in rebound for a horizontal travel of six inches, then in contact with the road for six inches, with continuous alternations of rebound and road contact. Accordingly the wheels will be in the air for fifty per cent of the time, which should afford opportunity for considerable rebound slip.

To calculate the slip it will be necessary to find the gain of displacement during the time of rebound. This requires the determination of the angular acceleration of the rear wheels. Two points must be noted in this connection. First, the engine torque will be partly spent in accelerating the fly wheel, clutch, propeller shaft, etc., and partly in accelerating the rear wheels and axles. Second, the acceleration of the rear wheels will be only $1/m$ th of the engine fly wheel acceleration, where m is the gear ratio.



As "a" travels to "e", "A" travels to "E", thus losing the distance EE' due to the tire "creep." The diagram is greatly enlarged and no account has been taken of the small amount of slip that occurs.

Suppose x per cent of the torque spent in accelerating the fly wheel and parts, while (1-x) per cent are spent in accelerating the rear wheels and attached parts. Then the angular accelerations can be expressed as u_1 and u^2, having the following values:

$$u_1 = \frac{Fg\,x}{I_1} \quad (1)$$

$$u_2 = \frac{Fg(1-x)}{I_2} \quad (2)$$

The value of x can be determined by comparing (1) and (2), remembering that $u_1 = 5\,u_2$, as before stated.

The value of x is found to be $x = .69$.

Inserting this value of x in (2) the angular acceleration is

$$u_2 = 10.9 \text{ radians per sec}^2 \quad (3)$$

The angular displacement in the time t will be,

$$\text{Angle of displ} = \tfrac{1}{2}\,u_2\,t^2 \quad (4)$$

The time for 6 inches horizontal travel will be 0.014 sec.

Angle of displ. = .00107 radians.

= .017 inches at 16 inches radius.

The conclusion from this calculation is that, during the six inches of travel off the ground, the wheel will gain .017 inches at the rim over a uniformly turning wheel. The slip will therefore be .017 in 12, or .14 of one per cent.

The mathematical deduction seems to indicate that the rebound slip must be very small per cent of the total, apparently only about one-tenth of the amount of "creep" which was estimated in a previous paragraph. The general correctness of the theoretical estimates seems to be confirmed by the experimental observations which will now be described.

Experimental measurement of slip has been made by counting the gain of revolutions of the rear tires when climbing a hill of uniform grade, and comparing same with revolutions of rear wheels on a very slight grade where no tractive force is required. In this comparison the tractive force of the tires is of considerable magnitude, and acting always in the same direction, on the up grade. On the slight down grade the tractive force will be practically zero; hence no slip will occur.

The apparatus consisted of a small revolution counter attached to each hub cap, with counting axis kept from revolving by a wire attached to the running board. Special Veeder counters were used, reading to 1/5 revolution. This error becomes negligible after making a test run of hundreds of revolutions.

Non-slip readings were made on the slight down grade, comparing average of two front wheel revolutions with average of the rear. Similar observations were made on the up grade climb, where the rear wheels made relatively more revolutions. The gain in rear wheel revolutions, expressed in per cent, was a measure of rear wheel slip. Runs of this kind were made on three different vehicles, at varying speeds and inflation pressures, with results given in Table I.

TABLE I.

(a) FORD Sedan, four miles of old bituminous macadam.
Weight, rear, 1,290; total 2,310 lbs.
Tires, 30 x 3½ cord.
Speed, av. 30 m.p.h. Grade, about 6 p.c.

Tire inflation	35	45	55
Slip, per cent	.86	1.08	1.17

(b) WILLS Roadster, ⅝ mile of old macadam.
Weight, rear, 1,950; total, 3,990 lbs.
Tires, 33 x 5.95 balloon cord.
Grade, 4 to 10 per cent.

Tire inflation	26 (Normal)	43 High)
Slip at 3 m.p.h.	1.7	1.68
" " 15 "	1.66	1.75
" " 20 "	1.69	1.96
" " 25 "	1.76	1.97
" " 30 "	1.86	2.03

(c) MACK 7½-Ton Truck, ⅝ mile of old macadam.
Weight, rear, 10,500; total, 15,500 lbs.
Tires, rear, 40 x 7 dual solid rubber.

Slip, 2 m.p.h.	2.1 p.c.
" 7 "	2.3 "

In commenting on Table I, it may be remarked that the conditions of the experiment were favorable for producing rear tire slip. The road bed was a partly worn macadam, on which rebound slip might easily occur. The grade on one of the hills was high, reaching 10 per cent on the upper slopes, which called for considerable tractive force at the driving tires, and was therefore favorable to "creep."

J. E. Otterson, of the Yale School of Fine Arts, whose cover design appearing with this issue, was the winner of the prize contest conducted by THE YALE SCIENTIFIC MAGAZINE.

The slow speed slip on such a hill may be credited to "creep," while the high speed slip may be credited to both combined, and the difference, if any, to rebound slip. These characteristics are brought out in the roadster runs, where the slow speed slip was 1.7 per cent, which may be credited to "creep," and compares well with the predicted creep of 1.5 per cene from a previous paragraph. At high speeds the slip was increased to 1.86 per cent, a gain of .16 per cent due to rebound slip. This figure agrees well with that deduced by mathematical calculation, and proves that but little slip can be produced by rebound of tires from the road, even with a fairly high powered car on a fairly rough road.

The slip of the solid rubber tires was somewhat greater than that of the pneumatic tires at low speeds. Greater slip might be expected in this case, because of greater thickness of the rubber tread, which will increase the creep characteristic. The increase of slip by rebound was small, due probably to the slow speeds that were possible with the heavy truck.

The Ford car was operated on less steep grades as it had less tractive force. This may account for the lower slip observed in these tires. The increase of slip at high inflation pressures was quite marked in this car, and indicates relatively more rebound slip. However, this does not contradict the general statement that rebound slip is a small quantity, even under conditions where it might be expected to occur.

The final conclusion from theory, and confirmed by experiment, is that tire slip is small and consists mostly of elastic "creep" of the rubber, which probably does not produce much abrasion and wear of the tread.

[EDITOR'S NOTE.—In the November issue of THE YALE SCIENTIFIC MAGAZINE Professor Lockwood will present the results of his tests of the effect of wind resistance on a number of different makes of cars at speeds up to fifty miles per hour.]

Chemists Come to Assistance of Surgeons

From Sense-Deadening "Cuca" of Peru They Have Evolved Modern Compounds, Making Possible Marvelous Technique of Local Anesthesia

By Prof. A. J. Hill, '10S

THE coca plant is a shrub which is indigenous to the slopes of the Andes. It is about six feet in height, and its leaves, which are bright green in color, resemble those of the tea plant in size and shape. It was apparently known by the Peruvians, long prior to the Spanish Invasion in 1524, that chewing of the coca—then "cuca"—leaves gave an exhilaration, which offset hunger and fatigue, and also gave a sense of well-being that was peculiarly delightful.

In the early days of the Inca dominion, the use of coca was monopolized by the monarchs, who prized the leaves so highly that they bestowed them as gifts, or offered them as sacrifices. Gradually the habit of chewing them became prevalent among the masses, and the native Peruvian was known as a "coquero" or coca-chewer.

It was quite natural that many of the invaders should succumb to the temptations of coca-chewing, and shortly after the Spanish conquest the Church and the Government of Spain endeavored, without conspicuous success, to legislate against this new intoxicant. Indeed, the early scientific literature on coca was distinctly controversial in nature, and dealt largely with the question as to whether the effects of coca chewing were harmful or beneficial. In the light of present-day knowledge, the habit is distinctly injurious to health.

Until the middle of the nineteenth century, scientific interest in coca was largely directed toward investigations of its above-described physiological properties. The rapid growth of organic chemistry during this period was instrumental, however, in arousing interest in the possibility of isolating the active principle of the leaves.

> *THE GREATEST future possibilities of science rest in the co-operation of its various branches—in synthesis of the results of co-ordinated research. The story of cocaine illustrates one phase of this team play among men in related fields. The chemist, bacteriologist, pharmacologists, and physicians are working side by side to-day towards one great goal—the conquest of disease.*

In 1858, Albert Niemann, a laboratory assistant to the famous German chemist, Wöhler, isolated an alkaloid which he named cocaine. In the description of their new compound, Niemann and Wöhler made incidental mention of its *numbing effect on the tongue*—a property later destined to revolutionize surgical practice. It is a striking commentary on the lack of imagination of mankind, that this observation of Niemann's was repeatedly observed by others during the next twenty-four years, yet its significance was more or less overlooked. This is the more remarkable in view of the fact that subsutaneous injection of cocaine was also known to produce insensibility around the area in which it was introduced. Apparently, endeavors to prove its value, or lack of value, as a narcotic overshadowed other considerations. Indeed, as recent as 1880, a British Medical Commission characterized it as a poor substitute for caffeine.

It is necessary at this point to digress, and consider briefly some of chemistry's contributions to surgery up to Niemann's discovery of cocaine.

In 1846, William T. G. Morton demonstrated conclusively in the Massachusetts General Hospital, that the inhalation of ether—an organic chemical—would produce unconsciousness and consequent insensibility to pain in operations.* This has been characterized as one of the ten greatest discoveries that have marked human progress. The technique involving the production of *total anesthesia* by ether as well as by other chemicals (nitrous oxide, chloroform, ethylene, etc.) has been developed from its early empiricism to a splendidly scientific basis.

Local anesthesia, or the production of insensibility to pain in some local area of the body, was apparently practiced in very early times.

It was first accomplished by pressure applied to nerve trunks and arteries, thus effecting the familiar "falling asleep" of hands and feet. Local application of opium-containing extractives was also used, although it is doubtful whether the deadening of sensory nerve endings was very effective by this method. Local anesthesia was also brought about by the application of cold, which was first produced by ice and salt, but later by the evaporation of volatile solvents, such as ether (Richardson's "ether spray," 1867) and ethyl chloride.

Prior to 1884, the only successful *local anesthetic* was Richardson's ether spray. Its unsuitability for eye anesthesia led Koller, a Viennese oculist, to search for a suitable chemical for this purpose. While collaborating with Freud in an investigation of the effects of cocaine taken internally, he was led to try it upon the eye, being aware of its numbing effect on the tongue. His experiments immediately revealed the value of cocaine in ophthalmic surgery, and he reported his discovery before a scientific gathering at Heidelburg in 1884. Koller therefore had the acumen to apply to surgery a physiological property of cocaine that had been observed by many scientists during the twenty-four-year period that had elapsed since Niemann's isolation of this substance from coca leaves.

The scientific importance of Koller's discovery was immediately recognized world-wide. Nor was its use restricted to eye surgery, for in the next year it was used in this country for spinal anesthesia, and its general application through appropriate injection of its solutions became common practice in all civilized countries. A new and very effective tool had thus been placed in the hands of the surgeon.

The important role of chemistry in medicine is splendidly illustrated at this point in cocaine history. Following Koller's dis-

* It was known previous to this date that ether and nitrous oxide would produce anesthesia.

covery, there ensued an intensive period of chemical research which led to the synthesis of this natural product, and to the establishment of its chemical constitution by Willstätter in 1901. Knowledge of the structure of cocaine soon made it possible to determine the particular portion of its molecule responsible for its local anesthetic action. This discovery in turn focused attention upon the synthesis of compounds less complicated than cocaine, but having similar physiological properties. This search for substitutes was also actuated by certain disadvantages attending the use of cocaine, namely, expense, instability to sterilization, habit-forming properties, and, above all, its toxicity. As the direct result of these endeavors, several valuable local anesthetics were synthesized prior to 1905, among them "*beta*-eucaine," and the spinal anesthetic, "stovaine."

The synthesis of "novocaine" (or "procaine") in 1905 marked another epoch in the history of local anesthetics. This compound, which was prepared by the chemist Einhorn and the clinician, Dr. Braun, is now used more extensively than any other local anesthetic. It is approximately one-seventh as toxic as cocaine, and quite as efficient, except in ophthalmic practice. It is not infrequently the sole anesthetic used in major operations.

The success attendant upon the preparation and effective use of novocaine then greatly stimulated interest in the synthesis of new local anesthetics, for the most part structurally similar to cocaine, but in some cases, and as a result of exploratory pharmacological work, radically different from the cocaine and novocaine types.

Until the World War, however, it was not fully appreciated that scientific progress in this interesting field could be effectively made only through co-operation of the chemist with scientists in the biological fields. Indeed, one of the outstanding developments, resulting from the Great War, is the nation-wide—in fact, world-wide—co-operative movement toward the combatting of disease by the application of pure science. This great movement is being characterized by a most remarkable kind of team play among scientists in related fields. The chemist is working with pharmacologists, physiological chemists, clinicians, bacteriologists, and physicians toward this great goal—the maintenance of the nation's health. To mention only chemical activities, the National Research Council has had, for some time, well organized committees investigating chemical problems in connection with local anesthetics, antiseptics, hypnotics, arsenicals, and many other equally important topics.

Returning again to the subject of local anesthetics, the reflection of this great co-operative movement is seen in the extraordinary output of new compounds having local anesthetic action, and in the work leading to a better knowledge of the intercorrelation of chemical constitution, physical properties and physiological properties. The methods of attack are far more scientific than they have ever been before. Although the ideal local anesthetic has yet to be prepared, the efficiency and low toxicity of some of the newer synthetics testify to the value of this concerted effort.

For several years, investigations of the above-described nature have been in progress in the Sterling Chemistry Laboratory. Many new substances have been prepared, and many are being synthesized at the present time. Progress in this work is being splendidly facilitated by the hearty co-operation of Professor Frank Underhill of the Yale Department of Pharmacology, who, with the help of his colleagues, has tested the physiological behavior of the new compounds. Professor Arthur D. Hirschfelder of the University of Minnesota has also rendered valuable assistance. Although no conspicuously powerful local anesthetic has yet been prepared, the pharmacological and chemical data have contributed fundamental information regarding organic chemistry configurations which increase, or decrease, local anesthetic properties, and have proved of distinct value in planning lines of research in hitherto unexplored fields.

It is a far cry from the poorly nourished coca-chewing aborigine of Peru to the present-day splendidly developed surgical technique for the production of local anesthesia. This evolution offers an unparalleled example of the influence of pure science on the progress of civilization. Local anesthetics have played an extremely important role in many surgical triumphs, and it is conceivable that greater achievements will be accomplished when the chemist can provide the surgeon with better chemical tools.

AUTOMOBILES TESTED IN LABORATORY

Mechanical Engineering Exhibition Includes Rolls Royce, Chrysler "80" and Many Other Demonstrations

On March 10th and 11th, the Junior and Senior classes of the Mechanical Engineering Division held an exhibition in Mason Laboratory to demonstrate the type of study in which they are at present engaged. All the equipment of the laboratory was displayed, and several of the machines attracted a great deal of attention.

A Rolls Royce chassis set up on the chassis dynamometer was used to show this method for the determination of the horsepower, fuel economy, maximum grade, tire and front wheel losses, as well as for checking the accuracy of the speedometer. A Chrysler "80" and specially fitted Ford engine, each connected to a separate dynamometer, displayed the methods of obtaining brake horsepower, fuel economy, and efficiency characteristics of the respective engines.

A great deal of interest was shown in the new Skinner Unaflow Steam Engine and the small, compound, marine engine. The former develops seventy-five horsepower and tests are frequently run on it by students to become acquainted with steam engine testing methods as well as to learn the underlying principles of this particular type of engine. Research on this engine is also under way.

Exhibits and demonstrations of Tycos thermometers and pyrometers, Taylor instruments, Crane high-pressure valves, New Departure ball bearings, and Bigelow boilers attracted large crowds, and added to these were numerous other features which lack of space prevents mentioning.

Navigation Taught by Use of Signal Lights

Lecture Rooms Turned Into a Harbor by Use of "Dark Night" Device Invented by Prof. H. L. Seward, of the Mechanical Engineering Department

(Reprinted from *The Marine Journal*)

AN ingeneous piece of apparatus to be used in teaching navigation has just been devised by Professor H. L. Seward of the Sheffield Scientific School. It is expected to solve the difficult problem of instructing pilots in the subjects of identifying lights on all classes of vessels, meeting and passing vessels in traffic at night, rules of the road, and lights used on yachts and on naval vessels.

Although text-books and pilot rules clearly define the characteristic lights required on all classes of vessels and in all situations, the student of navigation cannot actually visualize the arrangements thus defined. In the device perfected by Prof. Seward the actual light signals are flashed before the student so he can become familiar with them and get practice in distinguishing them.

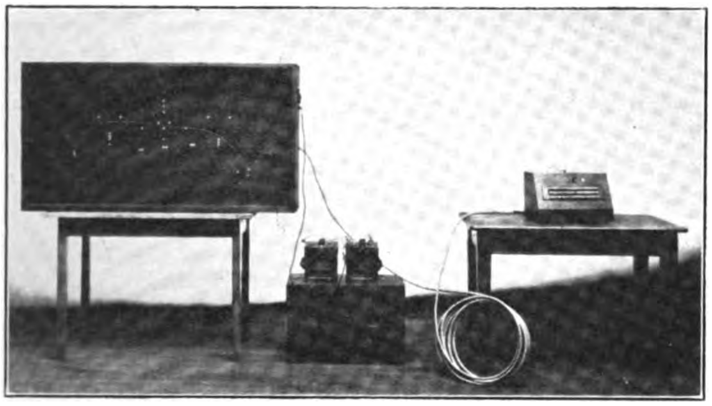


Fig. 1. "Dark Night" Device for Aiding Navigation Instruction.

The apparatus consists of three parts: the "dark night," the key-board, and the storage batteries which furnish the power.

The "dark night" is essentially a wooden cabinet about 30 inches x 60 inches, stained black and having 63 miniature 12-volt lamps and lenses similar to those used on telephone switchboards. A telephone cable 40 feet long connects the "dark night" with the operating switchboard of Fig. 3. On this switchboard there is a master switch marked "Bat" and there are 60 individual switches, each numbered and colored to correspond to the lamp or lamps controlled by that particular switch.

The actual relative arrangement of the lamps on the "dark night" board was made only after considerable study. Most of the lights are used again and again in the various combinations. Fig. 2 shows diagrammatically the arrangement of these lights, while in the photograph (Fig. 1) only the white lenses appear clearly.

The "dark night" can be placed at a reasonable distance from the observers, the long cable permits the instructor to sit behind or among the observers and all of the observers will see the same picture, even though they are located at opposite sides of the room. With the master switch open, the instructor selects the lights desired by him to illustrate a particular combination by using the individual switches and then closes the master switch. In the photograph, Fig. 1, there can be clearly seen a Long Island Sound tow of two tiers of barges (the tug having three high lights and showing port side to), appearing as if moving across the center of the field, bound to the observer's left. These lights happened to be lit when the photographer appeared. There are numberless other combinations to show ferry boats, deep sea tows, pilot vessels, fishing, patrol, cable laying vessels, all head on or on either beam, absentee lights, breakdown lights, speed lights and every conceivable combination. The use of the principles of perspective has been carefully developed.

Various traffic problems may be set up, whereby four or five vessels may be shown and the problem of meeting and passing may be studied. For example, one may discern five lights at the lower right hand corner of Fig. 2, three white, one red, one green. The red or green may be shown with the proper pair of white lights to indicate a steamer crossing your course. The red or green may be used to indicate a sailing vessel or a buoy (flashing if necessary); meanwhile other lights may be used near the center of the board for vessels at anchor, towing, not under control, passing, etc., so that a very real condition of traffic is set up.

Fig. 2. Light Arrangement.

The apparatus may be used to lecture with, clearly displaying the points being explained. It may then be used as a test, because by using the master switch, a combination of lights may be flashed on for a given length of time only. If the observers each are given a numbered series of ballots, they may separately write down the name, position or characteristics of a given display and later be marked on their accuracy.

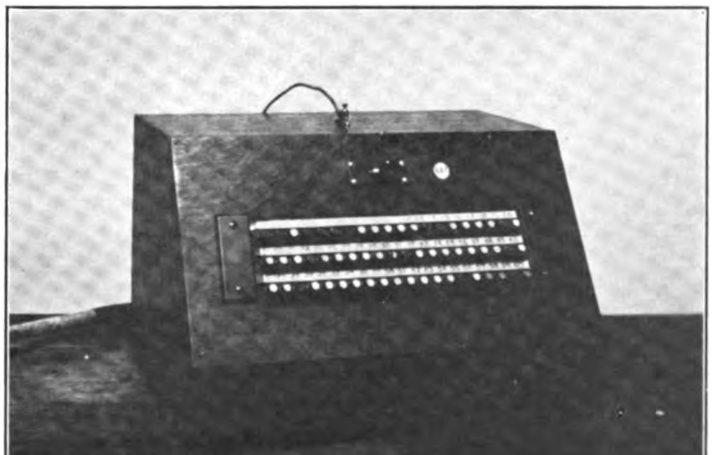


Fig. 3. Switchboard for Operating Light Combination.

At a recent exhibition, Professor Seward was successful in meeting all requests of his friends for particular combinations of lights called for, including such as: a tugboat having a high barge on one hand and a car float alongside, a man-o'-war, captain absent, commodore of the yacht club not on board his vessel at anchor, etc.

It is felt that better results are obtained by having each light on a separate switch rather than wired together in fixed combinations, so that traffic and changing situations can be studied. The instructor may, by properly operating the individual switches, give a sense of motion to the picture; for example, a sailing vessel may appear to have come about by changing a red to a green, a change in the angle of two white range lights may indicate a change of course of an approaching ship, etc. The same type of craft can be shown in several places on the board, a fact which tends to make the student analyze it, rather than memorize a picture. The device has been successfully used in instructional meetings of the Naval Reserve, the United States Power Squadron and in navigation classes.

YALE ENGINEERS TAKE INSPECTION TRIP

Industrial, Mechanical and Electrical Engineers Go As Far West As Dayton, Ohio, to Visit Plants

Engineering inspection trips were taken this year by three groups of Senior students, the Industrial, Mechanical and Electrical Engineers. The first two groups, under Prof. H. L. Seward, commenced their trip in New York on March 30th. In the party were Professors S. W. Dudley and H. B. Hastings, Mr. K. A. North, Mr. L. E. Seeley, thirteen Mechanical Engineering Students and fifty-six Industrial Engineering Students. This party visited the Waterside Power Stations, No. 1 and No. 2, and the new 14th Street Station of the New York Edison Company, the plant of the Western Electric Company at Kearny, New Jersey; the Atwater Kent Mfg. Co.; the Victor Talking Machine Co.; the Westinghouse E. and M. Co.; the Port of Philadelphia; Wm. Cramp and J. P. Morris Corporation; Electric Storage Battery Co., and Sears Roebuck Co. in Philadelphia; the Pennsylvania Railroad Shops at Altoona, Pa.; the A. M. Byers Company; the Carnegie Steel Company plants at Pittsburgh, Pa.; and the National Cash Register Company and McCook Field, U. S. Army Air Corps, at Dayton, Ohio. The party travelled in special Pullmans from New York to Philadelphia, Philadelphia to Altoona, and Pittsburgh to Dayton. Through the courtesy of the Pennsylvania a special train took the group from Altoona to Pittsburgh and on the short trips to plants near Pittsburgh.

The Electrical Engineering Trip commenced March 29th. This party was in charge of Professors C. F. Scott, and consisted of Prof. W. B. Hall, H. A. Haugh, Jr., and F. T. McNamara, and nineteen Electrical Engineering Students. The party visited the American Telephone and Telegraph Co., The Western Electric Company's Research Laboratory, and the Brooklyn Company's Hudson Avenue Station in New York; the Edison Lamp Works at Harrison, New Jersey; the General Electric Company at Schenectady, New York; the Niagara Falls Power Company's Echota Distributing Station, Reserve Plant and Main Plant, the Isco Chemical Company, Carborundum Co., and the Ontario Power Co. Plant, Niagara Transformer Station, and Queenston Plant of the Hydro-Electric Power Commission, in Niagara Falls; the Transformer Works of the Westinghouse Electric and Manufacturing Co., and the Farrell Works of the Carnegie Steel Company, at Sharon, Pa., and the plants of the Carnegie Steel Co. and of the Westinghouse Electric and Manufacturing Co., and the Duquesne Light Co. in Pittsburgh, Pa.

OUR CONTRIBUTORS

¶ *Theodore W. Case, developer of the Movietone, graduated from Yale in 1912 and began the study of law, but soon lost interest and started research work in the action of light on molecular and atomic structures. The thermo-microphone used with the DeForest Phonofilm was one of his earliest inventions. During the war he perfected a system of secret signalling for use by government submarines, employing Infra-red rays. Since the war he has been working on the development of a new photoelectric cell which will measure light as the eye sees it.*

* * *

¶ *Professor Arthur J. Hill, who writes in this issue on local anasthesia, is chairman of the National Research Councils Committee on Local Anasthesia. He graduated from the Sheffield Scientific School in 1910 and received his Ph.D. in 1913. He now occupies the chair of organic chemistry.*

* * *

¶ *Herbert L. Seward, whose device for teaching navigation is described on page 19, obtained his Ph.B. degree from Yale in 1906 and his M. E. in 1908, remaining as a member of the faculty. At present he is associate professor of mechanical engineering. During the war he developed and operated the U. S. Navy Steam Engineering School at Stevens Institute, with the rank of Lieutenant Commander, U. S. N. R.*

* * *

¶ *Professor Edwin H. Lockwood, who at present is working with the General Motors Corporation on the measurement of air resistance of motor cars travelling at high speeds, graduated from the Sheffield Scientific School in 1888, received his degree of M.E. in 1892, and his Ph.D. in 1901. Since this time he has been connected with the University doing research automobile testing, especially in automobile tires and radiators.*

* * *

¶ *Clifford A. Betts, Office Engineer of the Moffatt Tunnel, graduated from Yale in 1911. In 1914 he studied further at the University of Wisconsin, later going into enginering work, which brought him to the Moffat Tunnel. Mr. Betts is given credit by the tunnel commissioners for the perfect observations and calculations necessary for the work. The two ends of the tunnel when joined did not diverge as much as a fraction of an inch.*

* * *

¶ *Professor John Zeleny, who writes in this issue about electrical discharges through gases, graduated from the University of Minnesota, B.S. in 1892, where he was a member of Phi Beta Kappa, and Sigma Xi.*

He is the author of numerous papers in Physics, dealing more especialy with Electrical Discharges through Gases. Among his experiments are: Discharge of electricity, mobility of ions, photo electric effect, and the verification of Stokes Law in gases.

* * *

¶ *Professor James W. Toumey, who describes the Yale Research Forest in this issue, was dean of the Yale Forestry School for ten years. He graduated from Michigan State College and came to Yale in 1900, now being professor if Silviculture. He is in charge of the Yale forest at Keene, N. H.*

* * *

¶ *Dr. F. W. Roberts, who describes the latest methods of plastic surgery in this issue, graduated from Sheff. in 1920 and then studied medicine at Johns Hopkins, receiving his M.D. in 1924. He is at present assistant resident surgeon at the New Haven Hospital, where he is engaged in research in plastic surgery.*

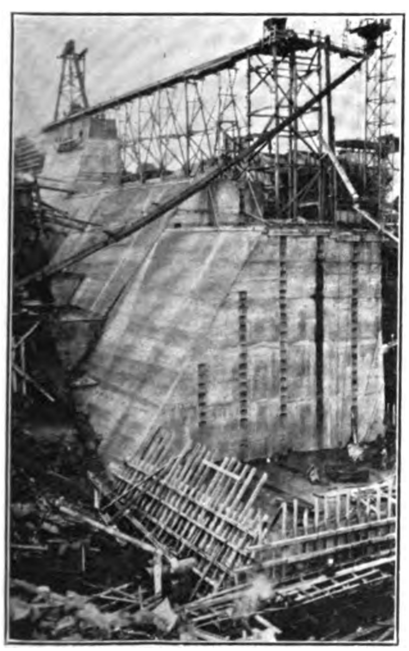
North Branford Dam Under Construction

Fifteen Billion Gallons of Water to be Trapped for New Haven's Use by Structure Twelve Hundred Feet Long and a Hundred Feet High

By E. E. Minor, 95S.

AN extensive addition to the supply works of the New Haven Water Company is now under construction at North Branford. The projects comprises a large storage reservoir in the town of North Branford, covering about 1,200 acres, and having a capacity of about fifteen billion gallons, eighty per cent of which will be available for use. The main dam is 100 feet high and 1,200 feet long, of concrete gravity section. The east dyke lies across a shallow valley east of the main dam, and is 30 feet high and 1,500 feet long. This is an earth dam with concrete corewall and carries the spillway for the reservoir.

The site of the main dam is in a narrow valley, with rock floor, the strata on both sides being in their true position. The rock is sandstone conglomerate and shale. Horizontal seams in general were tight, but vertical seams in the harder sandstone strata were somewhat open. The site was carefully explored by core borings and the dam located on a heavy gray shale bed 40 feet in thickness and having a dip of about 10 degrees to the east on line with the dam. This resulted in a rock cut on the west side of the valley 77 feet in depth. Additional precaution was taken by grouting under the dam through core holes. These were 15 feet to 20 feet in depth about 7 feet 6 inches apart and extend across the entire length of the dam near the upstream edge. Pipes were carried up through the concrete, and after 30 or 40 feet of concrete had been laid, grout under 100 pounds pressure was forced into the bed rock below.

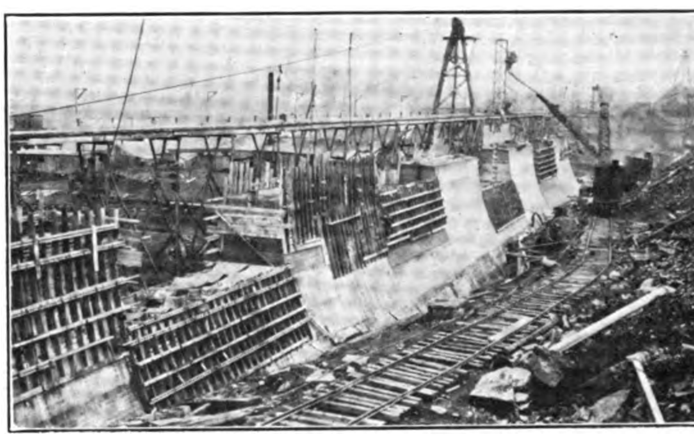


Twelve hundred acre pond requires huge bulwark to hold flood waters. Cross-section view of new Branford Dam.

The concrete is composed of 60% of No. 1, 25% of No. 2, 15% of No. 3 stone; the mix is approximately 1 - 2½ - 4½; water 1 to 1 ratio by volume to cement; and 4% of hydrated lime. Two one-yard mixers supply an elevator from which it is carried by chutes directly to the forms or onto a belt conveyor, from which it passes to the chutes. Cement is brought directly to the dam over a steam railroad about one mile in length, connecting with the Branford Steam Railroad.

The basin is a large valley eroded out of the sandstone shales lying on the main trap sheet which forms Totoket Mountain. This gives a reservoir one mile in width and three miles long, with a trap rock shore along the westerly annd southerly sides, the other shore being in sandstone.

The main gate house is entirely separate from the dam, standing 210 feet from shore and controlling outflow from the reservoir to a depth of 50 feet. It connects with a lined tunnel 66 inches in diameter passing under Totoket Mountain, which in turn connects with the main 48 inch feeder to the city. The location of the gate house saves 8,000 feet of pipe line, 5 feet frictional loss of head and provides a much clearer water than at the dam. The gate house is in duplicate, with screening chambers, tunnel entrance, control gates and ports for taking water at different levels. The operating gates for the supply, venturi meters and recorders and chlorinating apparatus are all located in a building on the west side of the mountain. It was not feasible to operate chlorinators or recorders at a depth of 50 feet from the surface.



A Quarter-mile of Concrete One Hundred Feet High. Photo shows pouring operations.

The main supply to the reservoir comes into the valley above the reservoir and consists of a tunnel 8 miles in length, which extends easterly to the Hammonassett River. Four controlling reservoirs will bring contributing streams into the tunnel. These are arranged to aid in holding back freshets or to by-pass the stream and still leave the tunnel free for operation. The grade of the tunnel is 1 foot in 800 and the maximum cross section is equivalent to a diameter of 84 inches. The grade capacity of the tunnel is about 200 sec. feet, but under full head this may increase to 300 sec. feet.

Additional supply is provided by a tunnel 4,000 feet in length and 72 inches in diameter under Totoket Mountain just below the head of the reservoir, which will bring in surplus water from Farm River, now flowing by our Saltostall Reservoir.

The project when fully developed will provide a safe yield of 40 million gallons per day. The storage ratio of 300 million gallons per square mile is high, but owing to the character of the water sheds, steep slopes and rock sides, high run-offs are to be expected. The large storage is especially valuable in enabling the Company to make fuller use of the storage in the many smaller reservoirs which it now controls. The main dam will be finished in 1927, the tunnels in 1930, and water available in 1932.

Dinosaur Footprints Found in Connecticut

First Evidence That Prehistoric Animals Existed in This District Uncovered by Yale Professors Near North Branford

THE sensational discovery of the footprint of a dinosaur in the Connecticut Valley has created a profound stir among paleontologists, who regard it as one of the most important finds in years. The almost perfect casting of the sunken imprint or spoor of the foot of a dinosaur pressed into stone and shale, and hardened by baking and burial through inconceivable ages was discovered by Dr. Carl Dunbar and Dr. Malcolm R. Thorpe, assistant curator of vertebrate paleontology in the University.

The scientific importance in this discovery lies in the fact that scientists did not know these dinosaurs wandered as far south as North Branford. Footprints of dinosaurs have been found in the Connecticut River Valley all the way from Turners Falls, Massachusetts, down to Portland and Middletown, Connecticut. But heretofore they have never been found below Portland, so that point was the southern limit of their known range.

The land in this vicinity is familiarly referred to by geologists as the Connecticut Valley, despite the present location of the river. The question is quite pertinent to the subject, and the apparent discrepancy in the location of this find is explained by the fact that for long ages, before comparatively recent influx of glaciers turned the course of the river eastward near the present site of Middletown, the water of the Connecticut flowed straight south in the direction of New Haven.

The largest of these Connecticut dinosaurs was probably not more than 22 feet in length, while those of Wyoming are known to have measured 75 or 80 feet in length. The marks of three toes, as shown in the photograph, which have a distinctly bird-like track, were the traces revealed by the excavations at North Branford, although what may have been destroyed by less fortunate blasts, or by the picks of workers more eager to construct dam foundations than to trail prehistoric creatures, will never be known. The creature that made the track was presumably only about six to eight feet long in the flesh, smooth-skinned and reptilian in form, with a small head and many short but sharp-pointed teeth. He had a small brain capacity, considering the bulk of his body, but undoubtedly had more brains than the herbivorous dinosaur.

Reproduction of the piece of shale containing the dinosaur footprint found near North Branford. This is the first record of the appearance of dinosaurs in this district.

As a general rule we find that the carnivore was not as large as the herbivore. He had to depend upon his agility to get his food.

The particular tracks which have been preserved on this occasion for the Peabody Museum collection, portray clearly the condition of the ground over which the reptile wandered. The nature of the rock tells the story of the climate. A wide mud flat, baked out by the sun, had formed the small, more or less irregular mosaic work of cracks that accompanies contraction of mud surface. Directly across one of these the dinosaur placed his three-toed foot, his weight partly breaking in the hardened mud.

The surface over which he walked, now hardened into rock, is on red sandstone and shale, and indicative of the aridity of this section during the Triassic period. In considering the fifty million years of leeway allowed in estimating the date of Anchisauropus tuberous' existence—for his date is set at 100 to 150 million years ago—it should be borne in mind that the dinosaurs flourished much longer as the most advanced and powerful type of life on the earth than the number of years since cold and aridity resulted in their downfall.

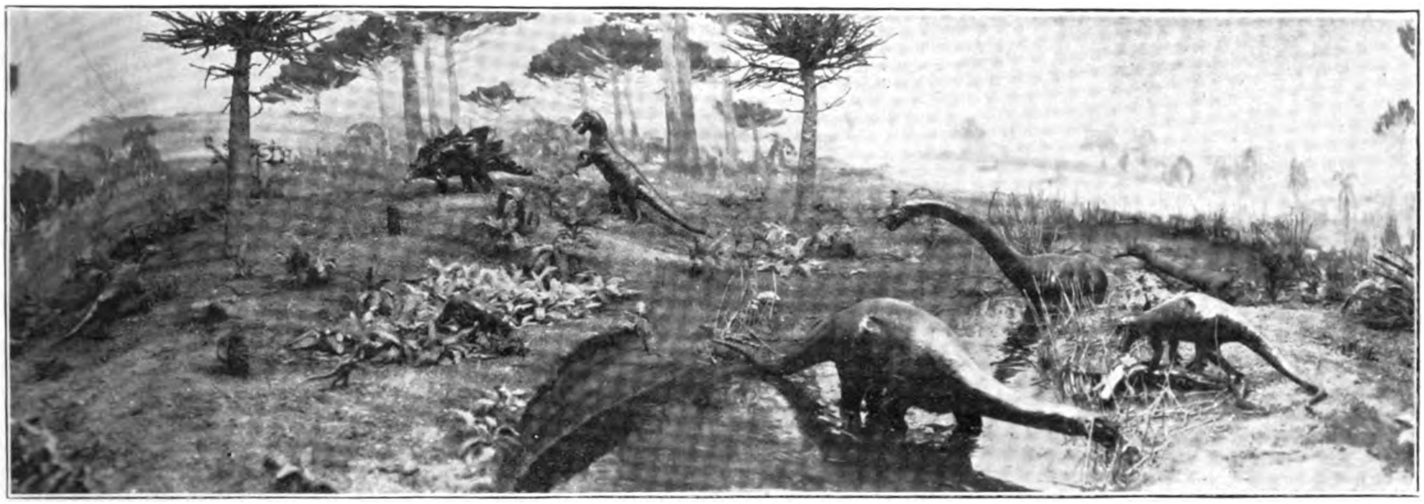
He was probably a great sprinter for a short distance, and employed much the same tactics in making his skill as do the carnivorous animals that we are familiar with today. That is, he lurked near the feeding grounds of herbivors and pounced upon them when their backs were turned. Sometimes we find the tracks of a herbivore showing where he turned abruptly from his course or doubled back on it, and we look around to find the tracks of the carnivore that frightened and put him to flight.

But how can one tell that this single, isolated footprint that was found at North Branford, was made by a flesh-eater?

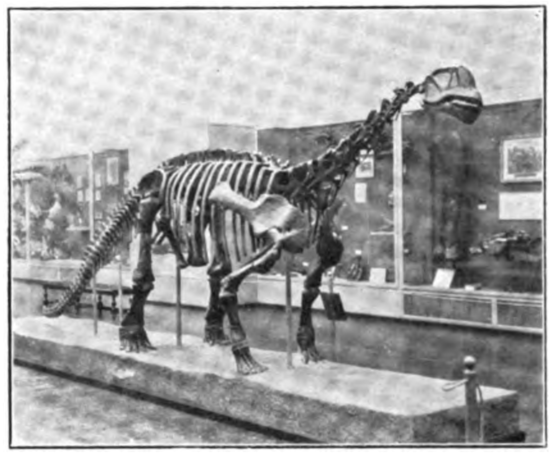
Dr. Thorpe tells us the general contour of the foot is one determining factor. Then, too, scientists have found that same footprint in other places, showing the claw marks very distinctly. There is almost as much difference between the foot of a carnivorous and a herbivorous dinosaur as there is between a tiger's paw and a horse's hoof.

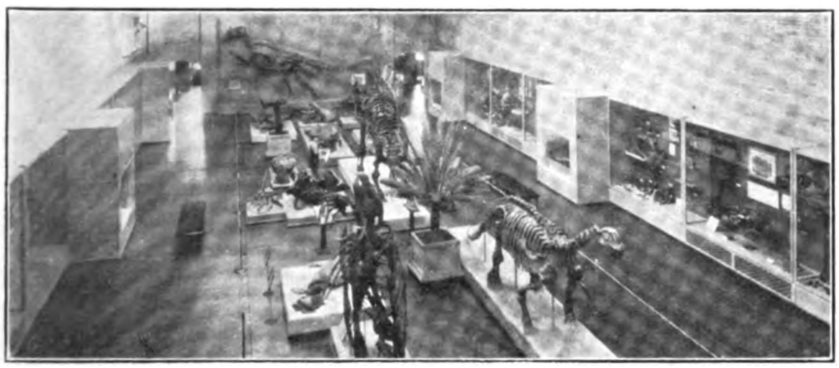
It was during what scientists call the Triassic period of time that the Connecticut River Valley dinosaurs flourished, according to Dr. Thorpe. This period is estimated to have begun about

(*Continued on page 42*)

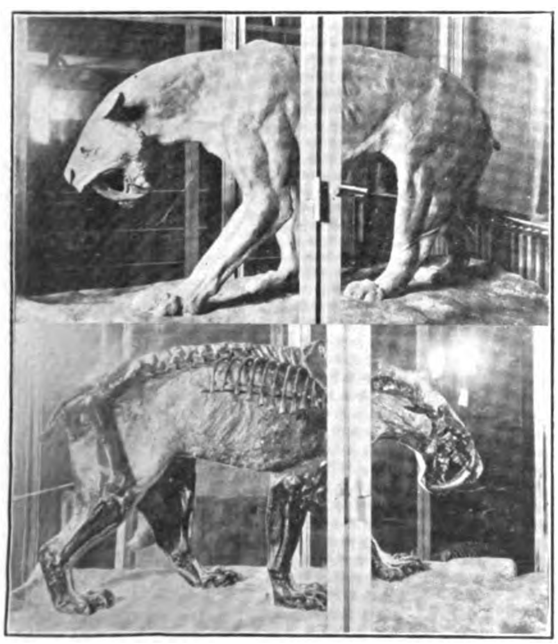


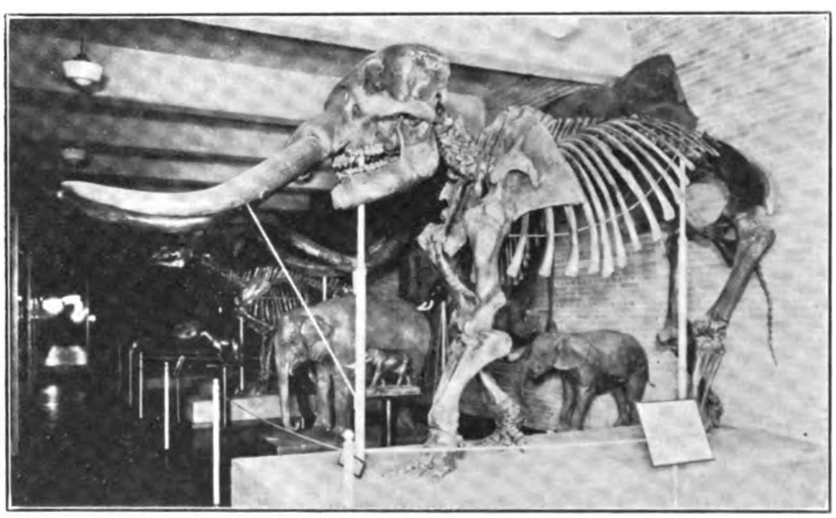
An effective method of presentation of dinosaurs has been introduced by Prof. Richard S. Lull, Director of the new Peabody Museum. Picture above shows the first natural habitat group of prehistoric animals ever displayed and includes models of specimens whose skeletons are mounted in the Great Hall. The group represents the principal sorts of dinosaurs which lived in what is now Wyoming, about 120 millions of years ago. At the right is pictured a young morosaurus, an amphibian dinosaur. Specimen is about half adult size. Below is a general view of the Great Hall. In the foreground is seen the only skeleton in existence of the largest known turtle, which was found in the Black Hills of South Dakota. Against the back wall in relief is the first dinosaur skeleton mounted in America, a duck-billed species.



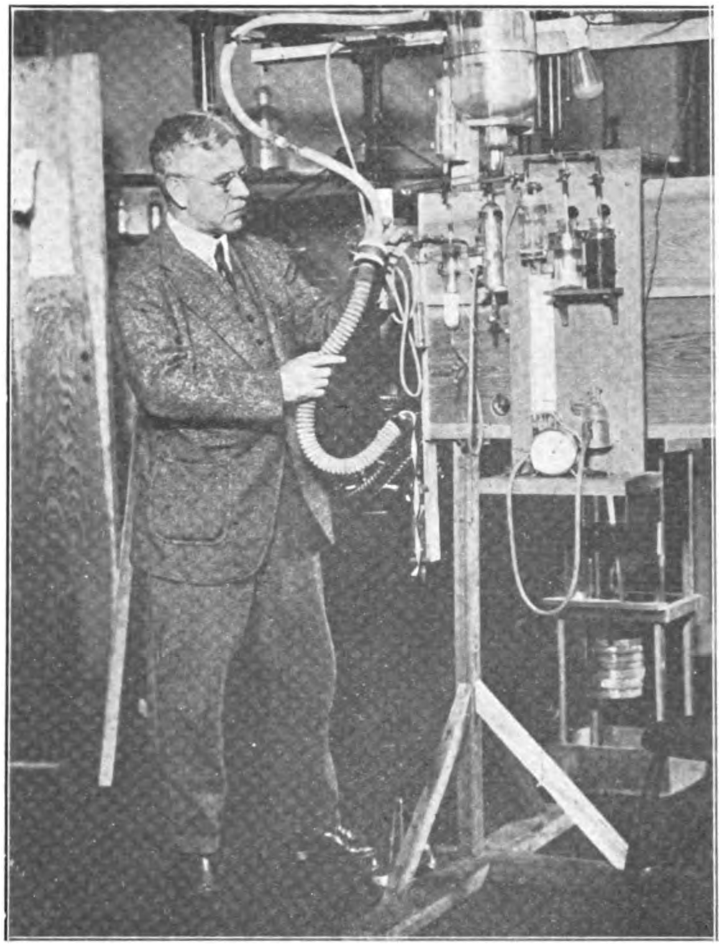


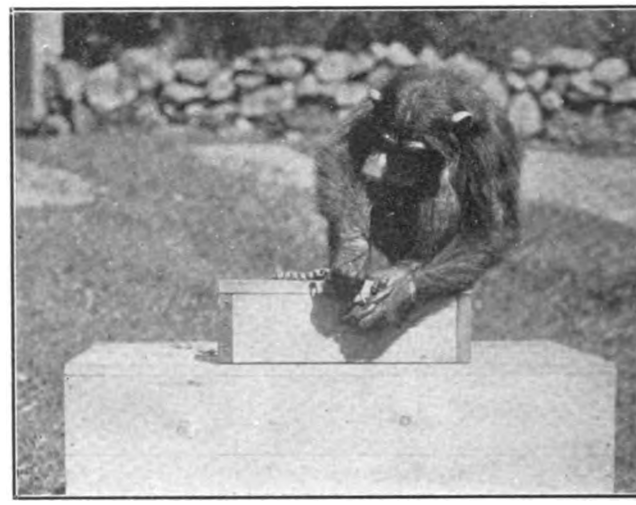
BELOW.—*Forerunner of the elephant—Mastodon mounted at Peabody Museum. The specimen is a partly grown female uncovered in a swamp at Otisville, Ky. In the background are two baby elephants; the one on the right is of the Indian species, distinguished by their large ears, while the other is an African specimen. Next to the mastodon is a skull of the Imperial Mammoth.*





LEFT.—*Example of another unique presentation first developed here at Yale by Prof. Lull. A Giant Sabre-toothed Cat from the asphalt deposits of Rancho La Brea, California, restored on one side, while the opposite half shows the skeleton. The modeling, as in the dinosaur group, is by Prof. Lull himself.*

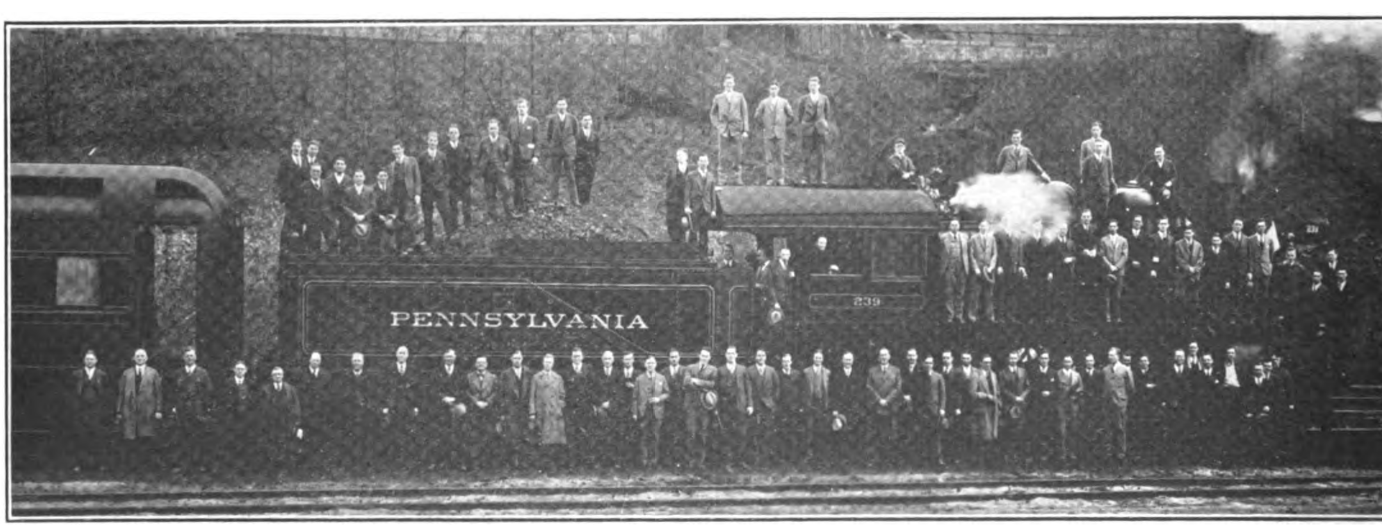




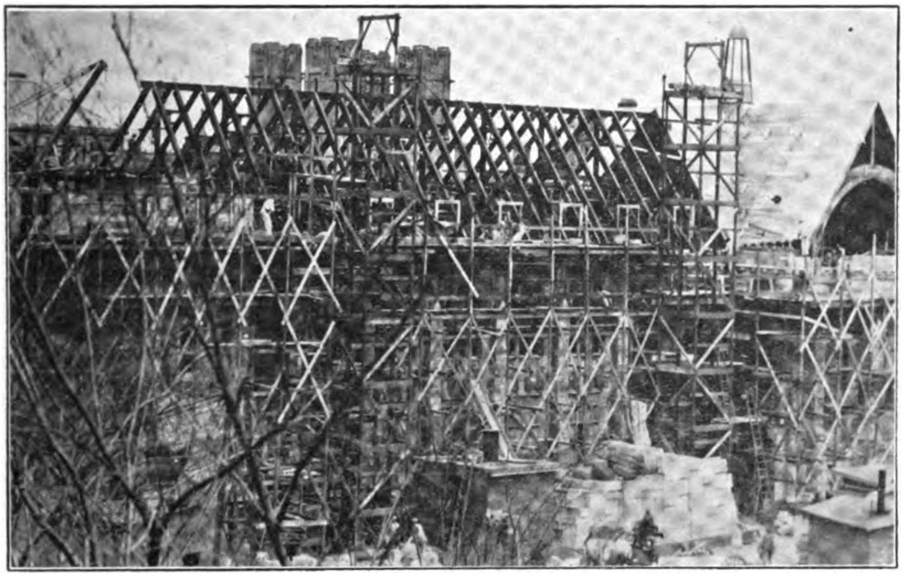
Dwina, chimpanzee of the Yale Primate Laboratory, Institute of Psychology, learning to use a key to unlock a box containing food. This experiment is one of a series conducted by the Primate Laboratory and is the first experimental research into the psychology of the apes under control conditions. Photo is from the collection of Prof. R. M. Yerkes, head of the Institute.

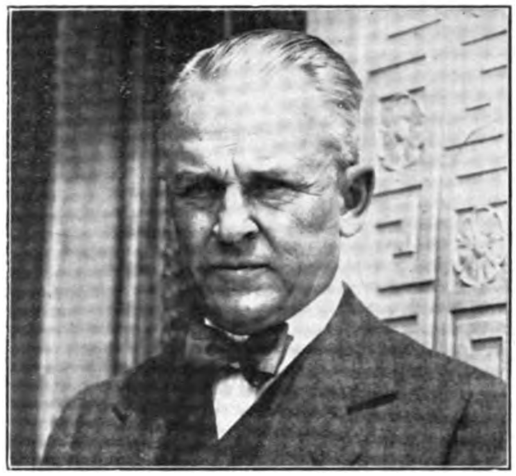
ABOVE.—*Dr. Yandell Henderson shown with the apparatus developed by the Department of Applied Physiology for measuring the effects of exercise on the volume of circulation. Ethyle iodide vapor is inhaled by the subject through the tube, the quantity varying with the rate of flow of the blood. The deparment has conducted experiments on crew men to determine the effects of exercise on the system.*

RIGHT.—*Prof. A. V. Hill, distinguished British physiologist, is conducting similar experiments on the Cornell Track Team in an attempt to determine the scientific components of running energy. Photo shows Prof. Hill testing pulse of runner who carries container for collecting air expired while running. (Photo by Wide World).*



Senior members of the Mechanical and Industrial Engineering Departments of Sheff. snapped on their Spring Inspection Trip at the plant of the Universal Portland Cement Co., at Universal, Pa., near Pittsburgh. The party was in charge of Prof. H. L. Seward of the Mechanical Engineering Department.





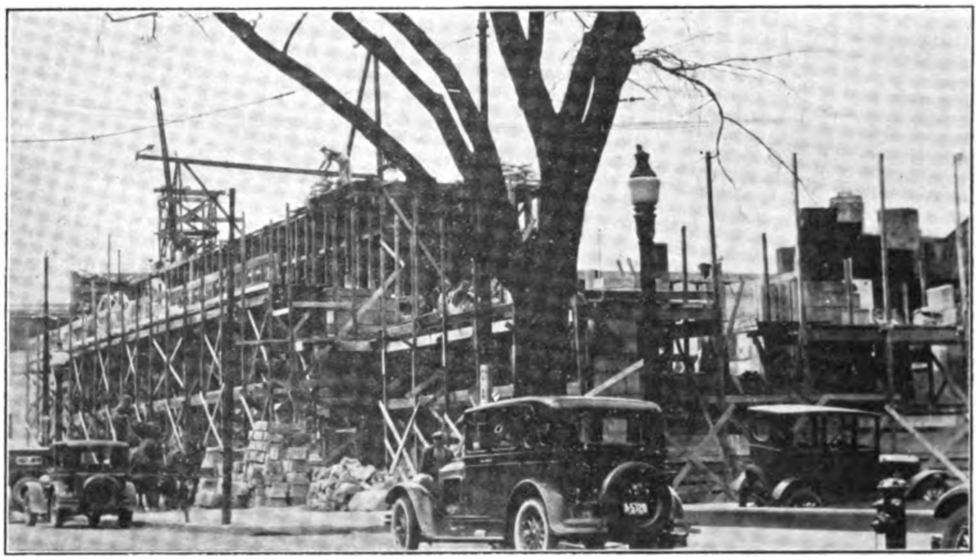
All electrons are spinning like tops as well as rotating in orbits inside their atoms, according to Dr. R. A. Millikan, above, who has just finished experiments verifying his theories. Dr. Millikan has lectured at Yale. (*Underwood*)

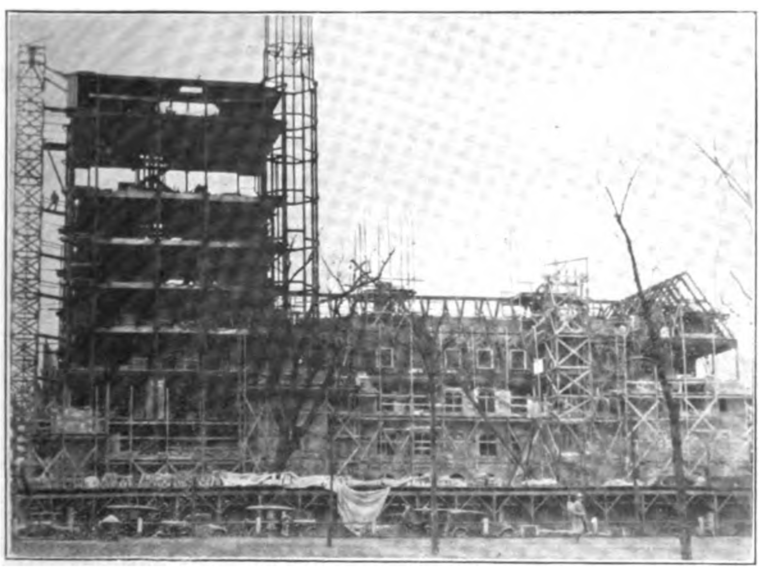
Construction on three of Yale's new buildings is progressing rapidly and they should be completed by the Fall.

ABOVE.—*Harkness Recitation Building as seen from the Freshman Oval. Its Gothic exterior will be a welcome addition, while its facilities will relieve the need for class room and office space.*

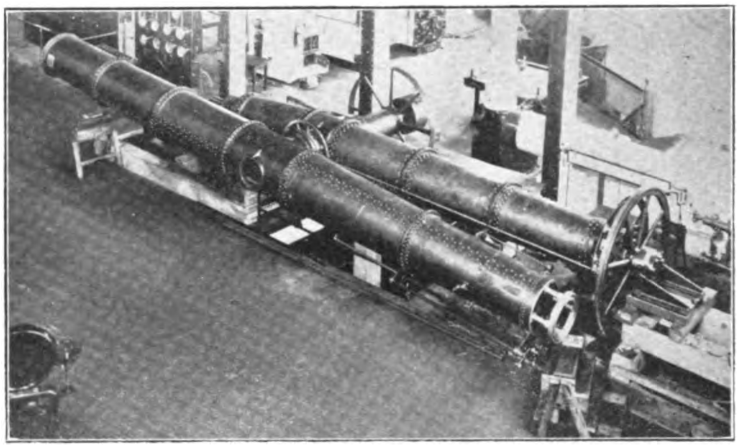
RIGHT.—*The new Art Museum at High and Chapel Streets will permit proper exhibition of Yale's collection of fine art. It will also relieve congestion in the Art School.*

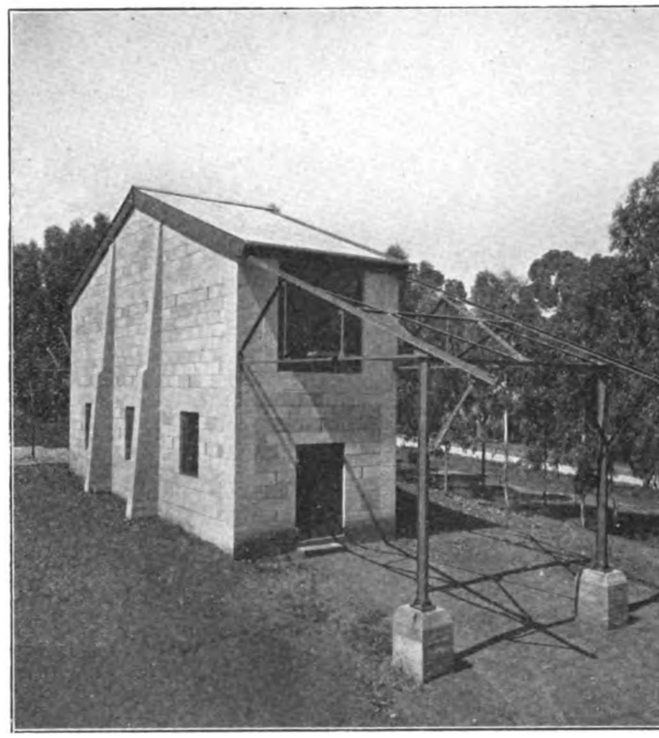
BELOW.—*Bingham Hall, the new dormitory which replaces the unsightly mass of Osborn, will surmount the southeast corner of the Campus with an impressive tower.*





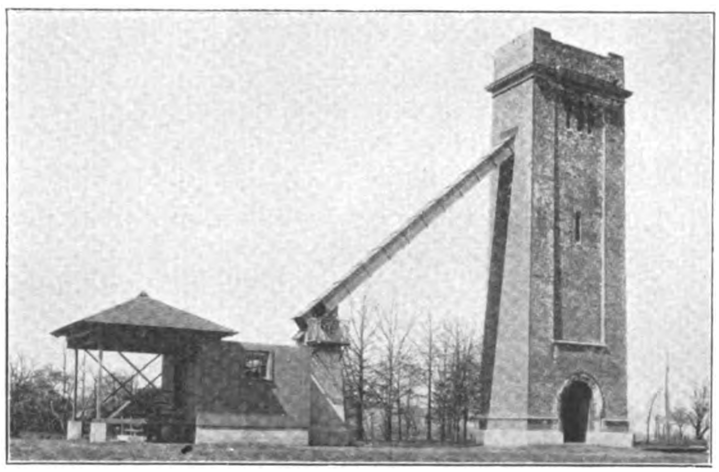
RIGHT.—*Dr. Barnett F. Dodge beside his bomb-proof cage in the Industrial Chemistry Laboratory of Sterling, where he will compress gases to the enormous pressure of 15,000 pounds. The potential bombs, the size of a twelve-inch shell, will contain hydrogen and carbon monoxide, to be passed over a catalyst in an effort to secure liquid products suitable for fuels and solvents.*





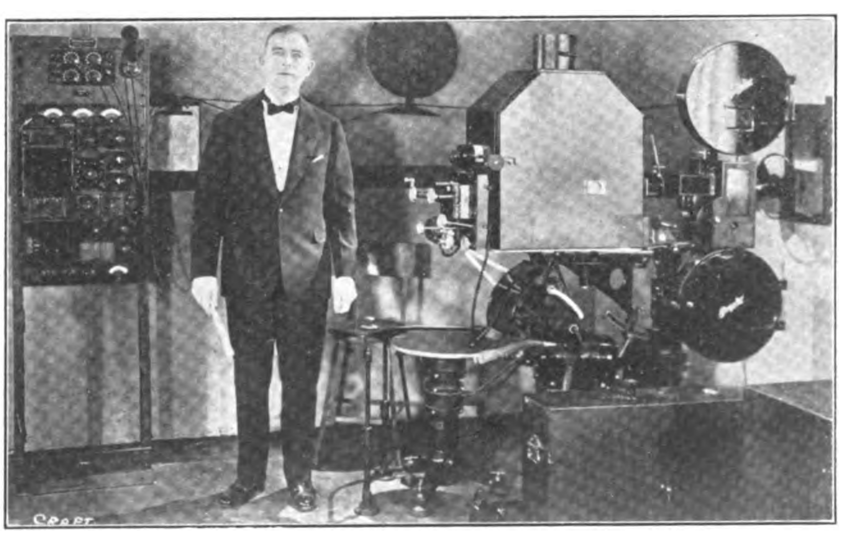
Yale's South African telescope assembled in the Mason Mechanical Laboratory preparatory to shipping to Johannesburg, South Africa, where it is now in operation. It is now mounted in the building shown at the right. This is the largest and most powerful telescope mounted in the southern hemisphere.

Dr. Frank Schlesinger, Director of the Winchester Observatory of Yale and one of the foremost astronomers of the country. He is especially noted for his work in measuring the distances of the stars.



ABOVE.—*Telescope building of Yale's recently completed South African Observatory. This station will allow study of parts of the heavens not observable in the Northern Hemisphere, and which will bear further investigation. The roof slides down on the iron frame to expose the telescope.*

LEFT.—*Tower and Mirror House of the Loomis Memorial Telescope at New Haven, the only one of its kind in the world.*



Dr. E. B. Craft, vice-president of the Bell Telephone Laboratories, illustrates the operation of the Vitaphone. At the right is the projection apparatus. Below is the turntable which carries the sound record. Both are driven by the same motor to secure synchronism. Newer developments in this field are described by T. W. Case, 1912, on page 11. (*Photo by Underwood*)

Dr. Lee de Forest, '96 S., pioneer in the development of radio, shown holding his new type radio tube, which will eliminate batteries and also furnish light. He founded the de Forest Lectures on Communication at Yale. (*Photo by Wide World*)

Yale Forest Reserve Is Working Laboratory

Thirteen Hundred Acres Devoted to Permanent Field of Forest Research and Public Education in Silvicultural Practices

By Prof. J. W. Toumey

NEW ENGLAND was completely covered with splendid virgin forests when settlement began four centuries ago, but today these forests have been so completely destroyed that they produce but a small fraction of the lumber needs of the region. The demand for lumber continues to grow more and more acute, and the time has arrived when New England must again grow her own timber from a supply standpoint if not from the realization of the fact that much of her land has no other economic use.

In developing a demonstration and research forest near Keene, New Hampshire, Yale has two objects in view—

First, the desire to instruct the public as well as students of forestry, in the economic possibilities of silvicultural practice by means of actual demonstrations in the forest on a scale sufficiently large to be convincing:

Second, to control an operating forest under sustained yield where the various operations incident to the management of a going forestry business are practised so that it may be a permanent field for forest research.

In the way of public instruction in practical forestry a special program is under way. The public is invited to visit the forest at any time during the summer months, when an assistant is available to show those interested over the forest, explain the operations under way, discuss the costs involved in the undertaking and the economic and other advantages that accrue from the silvicultural practice that they witness. This tends to stimulate private land owners to carry out similar operations on their own

Fig. 1. Noon hour at the Annual Field Day at the Yale Forestry Reserve. The assembled guests are listening to an address by Prof. Tor Jonson of Sweden.

land. It is entirely a process of teaching by example. Last season (1926), approximately 400 people visited the forest and were shown the operations under way and their import explained. An annual field day is held each year, the first Saturday in September. More than 100 people interested in forestry attended this gathering in 1926, many coming from adjacent states and a few from other countries. This field day, as shown in Figure 1, is given over to organized excursions over the forest to various points where silvicultural operations dealing with natural and artificial regeneration, liberation cuttings and weedings, thinnings and final cuttings are under way. Seven routes, each about two

Fig. 2. Entrance to the Forest. Following the twenty-five miles of roads through the reserve the reults of silvicultural treatment appear at every point.

miles in length, cover the forest over well-established roads. Stations marked with consecutive numbers, as shown in Figures 3 and 4, are established along each of these routes. A carefully drawn up description refers to each of these numbers, more than 100 in all. A visitors traversing one of these routes can by reading the description for each respective station, become informed on the former operations and the cost and profit from them. The results are shown on the ground.

The practical example of instruction by forestry practice is already showing its importance. This is not only shown in the many people who annually visit the forest and in the great success of our field day, but also by the many forest land owners applying the silvicultural operations witnessed here, to their own property. Books, pamphlets and lectures do not reach the public in the same way as actual operations in a forest that is a going business, and where these operations are shown to be economically profitable. Yale is carrying forward a unique piece of public education in forestry, by demonstrating to the practical and hardheaded forest land owners the possible chance for increasing profits that they may be overlooking, in not organizing their forest property for sustained yield and completely stocking it with valuable timber trees.

Although as a demonstration forest, this property has already gained an outstanding position, and is yearly attracting a larger public, it is as a research forest that it renders its best service to the School. The writer of this article is responsible for the operation and development of the forest work. He resides on the forest from the latter part of June to the middle of September.

This year the summer camp will be opened at headquarters in May, when the work with advanced students begins. The students who reside on the forest each year are engaged in research to be later submitted as partial requirements for the Ph.D. degree at Yale. Many stations located in various parts of the forest, such as the one shown in Figure 3, are for the purpose of studying some particular research problem.

Taking the Yale Demonstration and Research Forest as a whole, it has made remarkable progress since 1913, when the initial gift was made to Yale. The forest has progressively increased in size to its present area through contributions received from its friends. It is believed that others interested in this unique place of public education in forestry and in this splendid field for silvicultural research will make possible the attainment of our goal of a minimum of 2,000 acres, all in one forest organized as a practical going business where the public can see all the various silvicultural operations under way and learn how to apply them on their own land. This forest is already nearly self-sustaining,

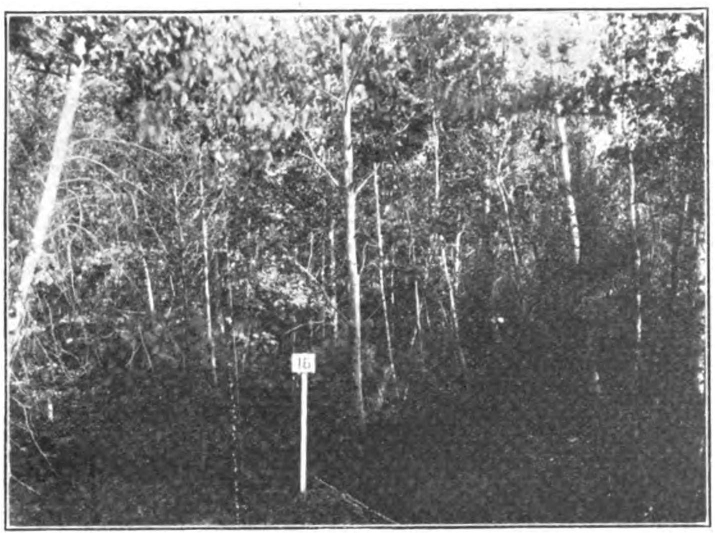


Fig. 3. Pine suppressed beneath a stand of inferior hardwoods. The hardwoods must be removed.

and in a comparatively few years it will produce a large net income which will add materially to the annual budget of the school.

The timber cut this year under the conservation program netted an income of over $1,000, and it is expected that this amount will increase materially as time goes on.

The forest has a present area of between twelve and thirteen hundred acres, all parts of which are accessible over more than seventeen miles of woods roads, some being suitable for motor travel. Passing along the highway beyond the entrance, the results of silvicultural treatment appear at every point.

The separate properties that have been acquired from time to time, during the past fifteen years, include large areas on which there was little or no commercial timber. This has necessitated a large amount of planting, as illustrated in the planting of 80,000 white pine in April of this year. Even where white pine was present, extensive liberation cuttings of birch and inferior hardwoods were necessary in order to free the pine, as shown in Figures 3 and 4.

George H. Myers, a graduate of the School of Forestry, deeded the nucleus of this forest to Yale in 1913. Since then, Myers and others have contributed funds for additional purchases. Two tracts were added to the property last year, and two others will be added the coming summer. It is hoped to increase the area of the forest to a minimum of 2,000 acres, through contributions received from time to time for this special purpose.

MEMORIAL LECTURES FOR PROF. GIBBS

Income of $250,000 Fund for Lectures on Physics, Chemistry and Mathematics Will Honor Great Yale Chemist

A memorial fund in honor of Prof. Josiah Willard Gibbs, great Yale chemistry teacher of the last century, was recently announced by the Yale Corporation. The income from the fund, which is expected to reach $250,000, is to be devoted each year to the work of the Department of Chemistry, Physics and Mathematics.

Prof. Josiah Willard Gibbs, who has been called "the first physical chemist of modern times," graduated from Yale College in 1858. He received the doctorate from Yale in 1863, and after tutoring at the University for one term, spent three years in Europe. In 1871 he was appointed Professor of Mathematical Physics in Yale University, a position which he held until his death in 1903. Many honors came to him in the way of degrees and medals, among these being the Rumford Medal from the American Academy, and the Copley Medal from the Royal Society of London. Although not in the strictest sense of the word a chemist, Prof. Gibbs is generally considered to have made the greatest single contribution to theoretical chemistry made by an American. In 1876-78 he published a series of papers on "The Equilibrium of Heterogeneous Substances." Because of the strictly mathematical treatment of the subject and the prevailing lack of familiarity of chemists with higher mathematics, its value was not recognized nor was the great principle involved used by chemists for several years. As a result some of the natural laws clearly stated for the first time in these papers were rediscovered by others, both from theoretical considerations and by actual experimentation. The principle now known as the "Phase Rule" evolved from Prof. Gibbs' mathematical discussion.

The great value of the "Phase Rule" in theoretical chemistry is recognized by all working in that field. The average man, however, does not realize the enormous practical use which is made of this principle first developed by Gibbs. The familiar carbon-iron diagram, which is the basis of the metallurgy of steel, is based upon it. The whole subject of alloys and the science of metallography is founded on this Rule. The classic work which has explained the constitution of portland cement was only possible through this Rule. These are but a few examples of its value and versatility.

Fig. 4. Showing the conspicuous manner in which each station is marked where operations are under way.

P - E - R - S - O - N - A - L - I - T - I - E - S

No. I *RICHARD SWANN LULL*

"26a Organic Evolution, 3 hrs,"—thus to every student in Yale the invitation is extended at some time in his college course to know Dr. Lull. And what a commonplace enough invitation!

To those of us who have accepted, who have sat in his classes fascinated by a keen intellect, and warmed in the rays of his genial personality, the following tribute will indeed prove an inadequate one. To those who have been unfortunate enough to have missed him, may these words serve in a small way to reprove such an oversight and to remind them of their loss.

The few facts here represented from his biography serve, as in the progress of every great man, only to remind you of the varied influences on a life of one increasing purpose. You probably know them already. Richard Swann Lull was born in 1867, the son of Captain Edward P. Lull, at Annapolis, Md., where he lived and grew in an atmosphere of culture and refinement. Here the lifelong love of the sea and its ships was undoubtedly nurtured. Here the keel was laid for a vigorous body and a brilliant mind. The hewn ribs and spars taking form in the ships he loves must have greatly influenced the young boy in these early years, for he gives off today something of the soundness and great wholesomeness of those old ships.

With this excellent preparation and a thirst for science, he entered Rutgers college. Combining a fine mind with a strong body, Lull was a scholar and athlete as well, being a varsity football man throughout his course. He graduated in 1893, a Bachelor of Science, with honors, and a member of Phi Beta Kappa.

From college he entered the entomology division — Department of Agriculture — of the government. Academic life called him, however, and the next year, 1894, after marrying Clara Coles Boggs, he went to teach at Massachusetts Agricultural College. He was assistant and associate professor of Zoology at "Aggie" until 1906, when he was brought to Yale and took a place in her list of famous scientists.

Along the route he grew as the true scholar, more and more turning his research to the branch of Paleontology and museum work. Interspersed with his duties as Curator and his classroom lectures, he found time to assist and direct in expeditions to Bone Cabin Quarry, Wyoming, and Hell Creek, Montana. Both these field trips have added tremendously to museum collections and evolutional evidence in general, and in particular to the evolution of the Dinosaurs.

His single connection with the student body is, as mentioned above, through the organic evolution course, wherein he takes his greatest pride. He has taught "O. E." for over twenty years without missing, through any fault of his own, a single class. This record of devotion is only the more strengthened by a decision this year to postpone a sabbatical sojourn for one term, in order that he might carry on. As a result he doubled his own work, satisfied his students, and remained loyal to his work and to his ideals.

In a group of middle-aged graduates at a recent Yale Club gathering, the talk turned to ideals, work, and inevitably back to college—what they really got from it that had endured. With surprising unanimity they admitted that college to them meant a personality—"old Prof. A or B"—and the man in some cases behind that A or B was "Uncle Dick" Lull. They had forgotten most of the facts, but in some manner he had helped them along; he had opened some window that gave them a glimpse of the stars, or a clearer view of the true meaning and higher possibilities of life.

A former athlete would never quite forget the enthusiasm and the sparkle in his eyes as he unfolded the story of the dinosaurs. There was something rich in his portrayal of the brontosauri, "those stupid slow-footed old boys." He would talk about them until the whole class could see them moving around in the flesh, a mountain of muscle and bone. Always Dr. Lull's pet lecture, this particular topic, for sheer color, remains for years in the impressionable mind as a masterpiece.

Another of the group remembered the care he took in describing the construction of a whale. It was his joy to point out "their perfect contour, a stream-line body, battering-ram head, and gigantic tail-flukes that could shatter a fair-sized boat." With what care he compared them to a magnificent ship, and professed that "never before had such a superb mechanism been portrayed on the face of the earth." He closed his course with that great "Pulse of Life" lecture in which he made clear his aim, his subject, and his own convictions. I can see him now with arms outstretched, and the words that have burnt themselves into many memories: "the great heart of nature beats, its throbbing, stimulates the pulse of life, and not until that heart is stilled forever will the rhythmic tide of evolution cease to flow."

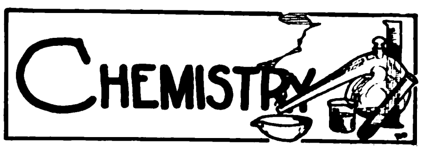
These fine pictures of the man, Lull, which one takes away, which one hears reiterated in the gatherings of former Yale men, make one want to question what it is that draws us to him. What is the quality or qualities that these men have that make them remembered, that make their personalities the surviving impression when one asks what you really received from college?

(*Continued on page 45*)

LABORATORY NOTES

Dr. Schlesinger Lectures in England.

Dr. Frank Schlesinger, director of the University Observatory, paid a short visit to England for the purpose of delivering the first George Darwin lecture to the Royal Astronomical Society on March 11th. His subject was "Astronomical Photography of Precision." This lectureship was recently established as a memorial to George Darwin (an eminent mathematical astronomer) by a former pupil, Dr. J. H. Jeans, formerly Professor of Physics at Princeton University, and now Secretary of the Royal Society. While in England, Dr. Schlesinger was presented with the Gold Medal of the Royal Astronomical Society, which had been awarded to him in January.



Sterling Chemical Laboratory.

Research is being carried on in Chemical Engineering and Organic Chemistry primarily.

Prof. H. A. Curtis reports Chemical Engineering research to be proceeding in three general fields: Study of high pressure gas reactions, study of fuels, and the conversion of the primary products of the air-nitrogen industry into other useful products.

Prof. A. J. Hill reports research in Organic Chemistry to be bio-chemical in nature. Work is being done on the synthesis of new and better anesthetics and hypnotics. The synthesis of new iodine-containing compounds is being studied since the discovery that the Thyroid Gland, containing iodine, plays an important role in the development of mental and bodily growth.

Prof. A. J. Hill and Dr. Laura Cannon (Yale Ph.D. 1921) are making a complete history, in the form of a monograph, of the chemistry of local anesthetics, in order to facilitate the work of research workers in this field. They hope to complete this monograph in another year.

Prof. W. G. Mixter, at present Emeritus Professor of Chemistry in the Sheffield Scientific School, has presented the Sterling Chemistry Laboratory with valuable platinum apparatus formerly used by him. The actual weight of platinum is approximately one pound.

Chemical Bacteriology.

In connection with the National Tuberculosis Association members of the staff at the Sterling Chemistry Laboratory are engaged in studying the chemical properties of the Tubercle bacillis and expect to attain far-reaching results in the arresting of tuberculosis. The field of chemical bacteriology is a new one, and it is thought that it will be of great aid to the science of medicine.

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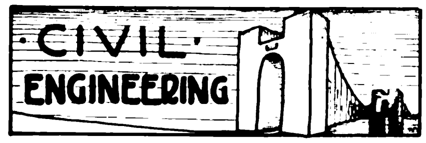


Yale Bowl Tablet.

On June 20, 1927, a tablet in memory of Charles Addison Ferry, '71 S., designer of the Yale Bowl, will be unveiled. The tablet will be placed above Portal 10 of the Bowl and the dedication exercises will be held there also.

This memorial has been secured through the efforts of the Yale Engineering Association, whose chairman, Ely M. Ryder, of New York, will be chairman of the exercises.

The tablet will be unveiled by Miss Ruth Ferry, daughter of the designer of the Bowl. It will be presented to the University on behalf of the Yale Engineering Association by Smith F. Ferguson, President of the Association.

The tablet will read:

CHARLES ADDISON FERRY
CIVIL ENGINEER

1852-1924
YALE PH.B. 1871 S.; C.E. 1891

DESIGNER OF THE YALE BOWL
THIS UNIQUE STRUCTURE
SHALL BE HIS MONUMENT
ERECTED BY
YALE ENGINEERING ASSOCIATION 1927

(*Continued on page 39*)

Yale Research Forest Now Open.

The headquarters of the Yale Demonstration and Research Forest will be open about May 10th. Several advanced students will be resident on the forest during the summer, engaged in research, the results of which will be later submitted as part of the requirements for their Ph.D. degrees.

Eight thousand white pine seedlings were set out on the Yale Demonstration and Research Forest this spring.

Professors on Leave.

Prof. R. S. Lull is at present on sabbatical leave for the half year. He is in Europe studying the geological museums there.

Prof. C. R. Longwell is on leave to complete the geological field investigation he is carrying on in the desert country of Nevada. The investigation will result in publications regarding the mountain structure of that region.

Mineralogical Collection in Peabody Museum.

Prof. W. E. Ford is completing the installation of the famous Yale mineralogical collections in the new Museum. He is also engaged in a revision of Dana's "System of Mineralogy."

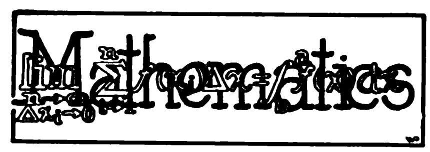
Investigation into Spanish Mineral Deposits.

Prof. A. M. Bateman is engaged in an investigation of the great copper deposits of the Rio Tinto in Spain, the results of which will be published shortly. He is also preparing material for a book relating to the general field of mineral deposits.

Connecticut Deposits Surveyed.

Dr. W. M. Agar is engaged in a field study of the geology of Connecticut, the

(*Continued on page 39*)



Professor Gives Gibbs Lecture.

Prof. James Pierpont has been very active in the study of non-Euclidian geometry. He has presented a paper on this topic at each meeting of the American Mathematical Society. Prof. Pierpont recently gave the Gibbs lecture in Kansas City on non-Euclidian geometry and relativity.

Work in Progress.

Prof. J. I. Tracey and students, Mr. J. H. Neelley and Mr. T. W. Moore, are at present carrying on work in the projective geometry of higher plane and space curves. Dr. L. T. Moore has been very active in this field.

Professors Beach, P. F. Smith, Longley and Behre have contributed sections to a new handbook on ore dressing.

Prof. W. A. Wilson has contributed some notable ideas in the recent development of analysis situs, which were pub-

(*Continued on page 42*)

BIOLOGY

Biology Notes.

Professors Woodruff and Harrison recently attended the annual meeting of the National Academy of Scientists held in Washington, D. C. Prof. Woodruff was appointed vice-chairman of the division of biology at the last meeting of the National Research Council.

Prof. G. A. Baitsell is now in Schenectady, N. Y., attending a meeting of the executive committee of Sigma Xi.

Work on the Fertilization of Protozoa Continued.

Prof. L. L. Woodruff and students are continuing work on fertilization in protozoa, based chiefly on a pedigreed culture of paramecia which, during the past twenty years, have attained some 1,200 generations.

Grafting of Embryotic Limbs Tested.

Dr. Nichols is transplanting embryotic limbs on a spotted salamander to test the effects of the graft on the adult organism. Dr. Harrison is performing similar tests on the ear.

ELECTRICAL ENGINEERING

De Forest Lectures.

In connection with the course in Communication Engineering established here six years ago, a series of DeForest Radio lectures have been given this year. Among the subjects of the lectures are "The Correlation of Some High Frequency Data," "Technical Problems in Transatlantic Radio Frequency," "Electron Tube Design," "Radio Transformer Design," and "High Frequency Transmission Phenomena."

Government Men Study Communication Engineering.

There have been more than ninety officers of the U. S. Army and Navy enrolled in the course in Communication Engineering, of whom about sixty per cent were graduates of West Point or Annapolis. The men are selected in a very detailed manner, the Army men being required to attend the Army Signal School or the Air Service School for one year preliminary trial, while the Navy candidates are sent to the Navy Post Graduate School. Only those officers who make a creditable showing are given the detailed course here. Since only the high grade men of the military schools elect this course, and the best of these are chosen, the quality of the work done in the course is very high.

When the men have completed the course they are put in charge of departments of the advanced communication schools, such as the Army Signal School and the Field Artillery School, or placed as instructors in West Point, while others become signal corps representatives in the office of the Secretary of War.

In addition to the service men eleven civilians have received their master's degree by taking this course.

Research Work.

Notable things have been accomplished by the research students in this department. They include the preparation of a transient visualizer which enables an observer to see what is taking place in an electric current, a visual indicator to replace the telephone receiver in determining when a Wheatstone Bridge is in balance, and the discovery of an unique property of electrical current which has been successfully used in measurement work.

PHYSICS

Outside Activities Engage Professors.

Professors Kovarik, Swan and Zeleny, together with Drs. Lawrence and Beams, recently attended a meeting of the American Physical Society.

Professor Swan recently delivered an address before a meeting of Sigma Xi at Columbia University.

Dr. Lindsay just published a paper on the carbon atom model and the structure of diamond.

Professor Swan is working on penetration radiation.

Professor Kovarik is working on the emission radiations from atoms in a crystal.

Professors Page and Ruark gave a series of lectures on recent developments in what is known as quantum dynamics.

Drs. Lawrence and Beams are continuing their interesting work on the study of time of production of certain lines in spectrum of light from definite elements.

MECHANICAL ENGINEERING

Prof. Lockwood Runs "Wind-Resistance" Tests.

Prof. Lockwood is at present engaged in making tests of "wind resistance" on automobiles. Up to this time manufacturers have had to use theoretical coefficients in figuring "wind resistance."

The method of collecting data in these series of tests is that of allowing a car

(*Continued on page 44*)

MEDICINE

Dr. L. S. Stone has been attending a meeting of the Association of Anatomists at Nashville, Tenn. ,

Dr. H. S. Burr has just returned from a half year's leave of absence, part of which was spent while studying the central nervous system in Kappers Laboratory at Amsterdam. He was also at the Queens Square Hospital, London, for a short time working on Neurology.

Dr. L. S. Stone has been studying the regeneration of the lateral line organs of the Diemyctelus.

Doctors Himwich and Chambers, together with Mr. Rose, have recently attended the meetings of the Federated Biological Societies at Rochester, New York.

Prof. I. V. Hiscock of the Department of Public Health in the Medical School left on the first of May for Memphis, Tenn., in response to the call of the United States Public Health Service for volunteer epidemiologists to aid in the supervision of the health of the flood refugees.

Mr. Usher, a senior in the Medical School, just completed an experiment on replanting the eyes of amblistoma and has been able to prove that vision was restored.

PHYSIOLOGY

Yale Professor Combats Inferiority Complex.

Dr. Howard W. Haggard, having observed the depression caused most people by the "Ask Me Another" books, has published a volume called "Are You Intelligent?" which is based on the U. S. Army "Alpha" Tests. In the preface, Dr. Haggard points out that the "Ask Me Another" books and similar series test merely the knowledge, which is a matter of observation and memory, whereas his tests require the use of power and reason. In the preface there is also a definition of intelligence, and a paragraph on the influence of heredity on intelligence.

Physiologists to Publish Book on Noxious Gases.

The American Chemical Society will publish in June a book "Noxious Gases," by Professor H. W. Haggard and Professor Y. Henderson, of the Department of Applied Physiology. The book, which will deal with the physiology of noxious gases, will be a unit of the monograph series of the American Chemical Society.

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Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

This department is prepared by the Yale Engineering Association. The Editors of the YALE SCIENTIFIC MAGAZINE are not responsible for its contents.

THE Yale Engineering Association salutes the undergraduates who have made the YALE SCIENTIFIC MAGAZINE possible. Taking an idea that found its beginning in the senior class several years ago they developed it and became convinced that much was being done in the School that was going unnoticed, and that not only Yale men, but the general public, should know these things.

The organizers of the magazine met with much opposition from all angles. Some said, "Too many magazines now." Others, "Science is too dry." And against such odds they were forced to pass on the idea unfulfilled to the present editors. As the idea was developed it was seen that there was a wealth of interesting happenings in the Yale Scientific family that would be of immense interest to the rest of the world. Here were Yale graduates building, planning, creating, and the world was passing by without hardly a glance.

And in Sheff. there was as great a field. Here were professors making research history. Dull stuff? Not a bit of it! The editors said, "Let us tell these things in a non-technical language, in simple words, so all will read. Let us deal with these vital matters concerning man's discoveries and contributions to the industrial and scientific life of the nation in a magazine of such compelling interest that it may eventually attract national if not international interest. By so doing we will bring added glory to Yale and its school of science and engineering.

Although there were shown to be no less than twenty-two scientific magazines published by undergraduates in other colleges throughout the country, all of which were found to be on a self-supporting basis, the organizers of the magazine found that it had taken all of them a long period of slow development to achieve a creditable position. The editors were ambitious that Yale's new scientific publication should not start as a four-page pamphlet.

And so an intensive investigation was made of the methods of securing circulation, advertising, and of the various policies the editors were using in securing the articles desired. But this took time, and as the year passed on it became possible that it would be another year before the publication could be launched. And so they came to us. We boasted of 1,200 members bound together by our interest in the Scientific School. Here were potentially 1,200 immediate subscribers to their new magazine.

Your officers pointed out the many dangers ahead of a new publication. We told them they needed capital. They raised it out of their own pockets. We pointed out the difficulty of securing advertising. They showed they could get it. And so finally we were convinced of the worthiness and possibilities of the publication. We would subscribe to the magazine for each of our 1,200 members, and for the time being would conduct a department wherein we would report this and that which might be of interest to our members.

But the idea of the magazine is theirs, and to them belongs all the credit. They put it together. Everybody realizes that the venture is an experiment, and that its success is consequently still a matter of doubt. But if all who come after labor with the zeal and intelligence of these who have started the magazine, there can be no failure. But, failure or success, we are glad to have marched in the ranks with these who have the future of Yale and its Engineering and Scientific School so deeply at heart. From ventures like this nothing but good can come.

THE news of the Yale Engineering Association will appear in these columns from now on. We have an arrangement with the editors of the magazine whereby eight pages are available for our use. What appears in these pages is entirely our own responsibility. The editors of THE YALE SCIENTIFIC MAGAZINE should in no way be held accountable for anything that we say.

What is set down here will be largely dependent on the activities of our officers and executive committee and the committee on university affairs. At present there is great activity among the officers, and particularly is the committee on university affairs hard at work. This committee is really a group of the Sheffield graduates who are laboring with great diligence and patience so that they may be of aid to the University in solving the so-called "Sheff. Problem."

This "Sheff. Problem" in its larger sense is merely one of making *all* Yale men realize the opportunity for service facing Yale in building a strong school of Science and Engineering.

At this writing President Angell has at hand a recommendation from the Committee of Deans regarding steps to be taken by the University to remedy some of the conditions brought about in the school by the reorganization. We particularly call your attention to the foregoing fact because it means that the University has a keen realization of the problem and has studied the facts. We can now expect action in the immediate future.

But no one or two things will quickly correct a condition that has been some time in the making. There will always be things to be done for Yale and for Sheff. We propose to mention and discuss some of those things. We do not propose to run a critical sheet. We do not propose to peek in corners for trouble. But we do propose to be frank. Frankness tempered with fairness can seldom be anything but a desirable quality. And it will be the surest way to achieve a common understanding.

There will be some who will say, "Hush, hush, you must not mention that." But if we see, for example, that the teaching in a particular course is outstandingly poor we intend to say so; if no one mentions it, it will always remain poor. We will run the risk of being called a disturber if the disturbance benefits in the best way Yale and Yale men.

Then, again, we see another value of this department. The undergraduates have had little opportunity to express themselves as to how they think Sheff. should be improved. Undergraduates can present these ideas in these columns if their discussions are of interest to members of the Association. The editors of the magazine will provide a place for other communications. In this department you will find several letters from undergraduates. We do not pretend to agree with what they say, but we do welcome their opinions.

Up to this time the Select Course graduate who has felt that Sheff. was ruined when his course was removed, the fraternity man who thinks that the present rushing system is poor, the non-fraternity man who thinks that the only trouble with Sheff. is the fraternities—these "grads" have all been unable to find a forum from which they could speak to an interested audience.

Here it is. Use it. You will get a load off your mind. That will do you good, and it may do Yale some good.

THE NEWS LETTER of the Association will not be discontinued. That will be sent to you as heretofore. It will not contain as much general information as formerly. It will deal more particularly with internal organization matters. We had already started to do in a small way with our News Letter what the undergraduates are now doing in a bigger way.

We are glad to retire in their favor. They are in a position to do a better job than we could hope to do.

A Message From President S. F. Ferguson

IT is a privilege to be able to send a message to the members of the Yale Engineering Association in the first issue of THE YALE SCIENTIFIC MAGAZINE. There could be no better medium of transmission.

First, permit me to extend to this new-born magazine the best wishes of the Yale Engineering Association for a long and successful career; also, the assurance of our interest and willingness to assist and support the magazine to the full extent of our ability.

At a recent meeting of the Executive Committee of the Yale Engineering Association, as President, I outlined what I considered the important work of the Association for the coming year. In order that the members may be familiar with the things we propose to do, the following is set down:

Committee on University Affairs.

This committee, no doubt, is one of the most important of the Association, as demonstrated by its constructive work in the past, under the able leadership of its chairman, Mr. Oliver S. Lyford. It gives me great pleasure to announce that Mr. Lyford has consented to continue in the position of chairman. The final report of this committee was submitted in January, 1926, to the officials of the University and has been most favorably commented upon by President Angell.

This committee, in collaboration with the Sheff. committee of the Alumni Advisory Board, submitted in February of this year, another report, which included practically all the recommendations of our first report to President Angell, with the additional recommendation of the advisability that all Freshmen, when entering, should indicate to which department of the University they intended to go after Freshman year.

Smith F. Ferguson, '94 S.,
President Yale Engineering Association.

Committee of Deans.

This report was referred to a Committee of Deans appointed by President Angell, together with instructions from him to report their conclusions after a careful study of the facts. The Provost of the University has very recently advised me that the recommendation of the Deans has been submitted to President Angell. It is quite probable that we will soon hear from the President as to his conclusions. Whatever the decision of the University officials may be, that is, whether our recommendations are accepted in total or in part, there will still be left a large amount of other constructive work to do for the benefit of Sheff.

This committee will be fairly large in numbers, composed of representative graduates. All of these are quite familiar with conditions in New Haven. It will probably be sub-divided into smaller committees, each to have its own problem to solve, so as to carry out the real object of this Association, namely, to be of benefit to the Engineering and Scientific Departments of Yale.

It is proposed to put into effect an organization for bringing before the students of the principal preparatory schools throughout the country from which Yale draws a large number of its students, information concerning what an engineering and scientific education means and where it leads to in the business and professional world.

It is undoubtedly true that the boys in the preparatory schools, their masters and parents, are not as familiar as they should be with the splendid courses which are now given in Sheff. and the great advantage to be gained therefrom. It is our hope to be able to arrange to assist the Sheff. faculty in this work by having some of our most prominent graduates, like Mr. E. M. Herr, General W. W. Atterbury, Mr. Francis Pratt, Mr. John Hayes Hammond, and others visit the preparatory schools and address the boys. The constructive and beneficial effect of the teaching staff and boys at the preparatory schools to have these men, who have attained great eminence in the business and professional world, appear before them should be very helpful in every way.

Additional Dormitories for the Scientific School.

There can be no doubt that one of the greatest needs today of the Scientific School is adequate dormitories, the lack of which is a serious obstacle to the development of campus life. It is hoped that sometime in the near future this problem can be solved, and this Association will use its very best efforts to attain this end.

New Building to Replace South Sheff.

Even though alterations have to some extent improved the appearance of this building, we are quite firmly of the opinion that this building has served its day and should be replaced by a building more in keeping architecturally with the other recently constructed buildings throughout the University. The location is doubtless the best in New Haven for a dignified, beautiful building, which should typify what the Scientific Department stands for. It is our intention during this year to have some studies made and preliminary sketches prepared for a new building for that site, with the hope that the necessary funds can be found for its construction.

The Increased Membership.

We now have a committee which has been working for the past few months to increase the membership of our Association, with the result that it has obtained about 200 additional members, so our membership is now about 1,350. It is the earnest desire of our Executive Committee to have our membership by the end of 1928 at least 2,500. This should not be a very difficult task, if all our members would give a little time to assist this committee by inviting others to join.

There are at least 10,000 Yale graduates actively engaged in

engineering, scientific work and industry who should be glad and willing to join us in the work of the Association. *Every Yale man, whether a Sheff. or an Academic graduate, should be interested in the problem of maintaining the highest type of engineering and science school in Yale.* The faculty and graduates have a responsibility to keep in the front rank, the Sheffield Scientific School, which blazed the trail under the able leadership of men like Professors Brush, Lounsbury, Brewer, and Chittenden—a very remarkable group of men.

In closing, there are other activities of importance, which will be taken up by the Association, but it is our feeling that these should not be announced until after the Endowment Drive is completed, for it is quite proper that most of the energies of all Yale men should be given just now to bringing that large task to a successful conclusion.

UNDERGRADUATES FEEL THAT ACADEMIC HAS A PROBLEM TO FACE IN OVER-POPULATION.

Following are the findings and recommendations of Combined Student Councils of Yale College and Sheffield Scientific School:

The Combined Councils reported recently that they believed that under the present system Yale College is over-populated and the Sheffield Scientific School is under-populated, and for the following reasons:

I. An artificial preference caused during Freshman Year, be-because of:
   a. Unsatisfactory instruction in elementary scientific subjects.
   b. Proximity of Freshmen to the College.
   c. Lack of all effort to acquaint Freshmen with opportunities for study in the Scientific School.
   d. Emphasis put on the Academic Course of Study at the meeting for the decision of courses in the Spring of Freshman Year.
   e. Unconscious influence of the *Yale Daily News*, which is almost a Yale College paper.
   f. Unsightliness of the Scientific School as seen by the Freshmen.

The Combined Councils believe that the foregoing influences may be remedied by providing:

1. That the teaching of elementary scientific subjects be improved.
2. That a meeting of the Freshman Class be held at the beginning of the Second Term, wherein the possibilities of study in both schools be presented by capable men in a helpful and impartial manner, and that this same plan be carried out at the final meeting for the selection of courses.
3. That the Freshmen be admitted into the Club Houses of the Scientific School at specified times throughout the year.
4. That the Vanderbilt (Sheff.) Campus be improved in appearance and be no longer used as an athletic field.
5. That money be allotted for the replacement of some of the more important buildings of the Scientific School and for the erection of new dormitories.

II. A natural preference for the College.

RESULTS OF SHEFF. UNDER-POPULATION.

They further state in their report that they believe that under-enrollment in the Sheffield Scientific School is responsible:

a. For enormous expense of large, fully equipped laboratories which are being used only to a small extent of their capacity.
b. For the inability to improve the variety and quality of instruction of which the school is now capable.

and that over-population in Yale College is responsible:

a. For the loss of class unity and class sentiment which formerly gave to each member a personal interest in his classmates and in his class as an organization.
b. For the lack of appreciation of Yale College and her traditions as evidenced by the undergraduates' sentiment and demeanor in recent years with respect to the compulsory chapel "family prayers," the Freshman-Sophomore Rush, the Honor System, Derby Day, Omega Lambda Chi Day, the Whiffenpoof Show, and informal functions such as the old Campus glees and the senior privileges which are no longer in the ways of Yale.
c. For destroying the individual's place in the College and for depriving many men of a personal connection with Yale life.
d. For the resulting lack of a lasting attachment to Yale as evidenced by the small numbers who have represented the more recent classes at their reunions.

The combined Student Councils of Yale College and the Sheffield Scientific School feel that the desired conditions may be reached only by a readjustment of numbers in the two schools, and propose:

I. That the selection of the College or Sheff. by the individual applicant for admission to Yale be made previous to his admission to the Common Freshman Year.
II. That each school have control of the selection of its applicants and the limitation of its numbers.
III. That the men admitted to the two schools be combined into a Common Freshman Class under the Common Freshman Year Administration.
IV. That the two schools co-operate as they see fit in the exchange of men who at the end of their Common Freshman Year desire to change their selection.

PERSONALS

Vance C. McCormick, '93 S., was an interested listener to Commander Ellsberg's amazing story of patience in raising the S-51. Commander Ellsberg addressed the recent meeting of the Association held at the Yale Club. Facts concerning the meeting were reported in the *Yale News*, and will not be repeated here.

C. R. Black, Jr., ex-'17 S., Captain of the 1916 football team, which defeated Princeton 10 to 0 and Harvard 6 to 3, has just joined the Yale Engineering Association. Mr. Black in a recent statement said that he believed all select course graduates should join the Yale Engineering Association, since it was really a Sheffield Alumni Association.

George S. Moore, '27 S., now chairman of THE YALE SCIENTIFIC MAGAZINE, will be Assistant Editor of the Yale Engineering section of this magazine on graduation.

The New York Port authority was recently called a "Super-Government" by Gov. George Moore of New Jersey. Secretary Wilson of the Yale Engineering Association is also Secretary of the Port Authority. That makes him a Super-Secretary. He is.

Samuel Insull, Jr., '21 S., of Chicago, is now taking an active interest in the affairs of the Association. He is going to invite the Sheffield graduates in Chicago to hear Oliver Lyford discuss the "Sheff. Situation."

Mr. E. M. Herr, '84 S., says that the Association should have over 2,000 members.

A memorial tablet will be erected at the Yale Bowl by this Association in memory of the designer of the Bow, Charles A. Ferry. E. M. T. Ryder, '96 S., a life-long friend of Mr. Ferry, is chairman of the committee in charge of arrangements. A special notice will be sent all members or details will be published in the *Yale Alumni Weekly*.

COMMITTEE PERSONNEL FOR 1927.

The following committees were elected at the annual meeting of the Yale Engineering Association, held at the Yale Club, March 30th:

Committee on University Affairs—Oliver S. Lyford, chairman, Mortimer H. Alling, Henry Brewer, Horace B. Cheney, W. E. Dowd, Jr., Samuel Insull, Jr., Chester J. LaRoche, Francis C. Pratt, Henry S. Pickands, A. H. Rudd, John M. Satterfield, Seth E. Thomas, Jr.

Committee on Admissions—E. M. Herr, E. M. T. Ryder, C. R. Beardsley, W. E. Dowd, Jr.

Ferry Memorial Committee—E. M. T. Ryder, chairman, Prof. Samuel W. Dudley, Smith F. Ferguson.

Committee on New Membership—Warner S. Hays, chairman, Chester J. LaRoche, Prof. Samuel W. Dudley.

Committee on Yale Engineering Review—E. M. T. Ryder, chairman, W. E. Dowd, Jr., Chester J. LaRoche, Oliver S. Lyford.

Publicity Committee—Chester J. LaRoche, chairman, Billings Wilson.

Meetings Committee—W. E. Dowd, Jr., chairman, Emerson R. Newell, Billings Wilson.

Auditing Committee—E. M. T. Ryder, chairman, Albert L. Webster.

COMMUNICATIONS

In this department we shall be glad to publish letters of interest to our members. All communications must be signed, but names will not necessarily be published.

[*One of the most important things in a college is that the students should be wide awake and thinking for themselves about current matters that are worth while. They don't always think right; in the majority of instances, perhaps, their statements may be wrong. If they were always right it would mean they were taking them second-hand from some book written by a man older and wiser than themselves—President Emeritus Arthur T. Hadley.*]

IS THE COMMON FRESHMAN YEAR UNSATISFACTORY?

Editor Yale Engineering Notes:

Why is the College over-populated? Why is Sheff. under-populated? These questions up to a few weeks ago swelled the balloon of Yale's 1927 problem to enormous proportions. Unlike its predecessors, however, this 1927 model has subsided quietly with no other result than a soft sigh.

In a few days, if it hasn't already been done, some 700 odd freshmen will come out of Battell Chapel potential Ac. or Sheff. men. The last minute stampede to Ac. has again been repeated, and the ratio is again 70 to 30. Sheff. is again on the short end—the above-mentioned questions are no nearer being answered. The problem is created anew when they leave the Chapel. The balloon has been justified.

What has happened to these freshmen in their year together? An answer to this might show why the freshman is led to make his particular choice. It might show why Sheff. is under-populated—why the College is over-populated—whether the freshman year is satisfactory. And it might not!

Among the happenings in his freshman year are the exposures that effect materially a man's choice. There is the one that brings him in contact constantly with College men or names, right smack in the College's back yard.

There is the exposure of the prep school group, with a leaning for Sheff., to the native son who is going into rug-making in earnest; to the honor lad from Podunk High with a thirst for aniline dyes; to the pre-medic who says in loud tones, "Yeah, I'm going to Sheff., sure, ain't you?" The prep school crowd begin to open their eyes. "If that's the kind that are going Sheff., we'll go Ac."

It is in freshman year that he is exposed to the social life. The fraternity side of the College is seen and listened to, and life in Sheff. is heard of, with its house system. The conscientious one looks at himself. Is he good enough to make a Sheff. house? Maybe not, and life "outside" in Sheff. would be bad. But he sees it doesn't make much difference in Ac.—everyone lives in dormitories. He'll go Ac. he guesses.

And then the most important exposure—the comments on the men who teach. The freshman is constantly hearing the praises of this man and that, and so-and-so's course, how Mr. A does it, etc. Some are praises he has heard before coming to Yale. Who are these men? They are not Sheff. names or Sheff. courses. "Think of all those chances to have them," he says. And he guesses he'll go Ac.

Thus the freshman makes his choice, colored with this new social outlook, with new educational possibilities, with a series of Academic exposures that have included Mr. Gamble Rogers' new fraternities and quadrangles, and is loath to leave "the center of things." This is what in a small measure has happened to him in his Common Freshman Year, and it *is* unsatisfactory.

R. B. M., '27 S.

CONCERNING THE COMMON FRESHMAN YEAR.

Editor Yale Engineering Notes:

The present situation of Yale College shows that it is overcrowded; that of the Scientific School shows that more students could be advantageously accommodated. The *Yale Daily News* called this to the attention of its readers some time last winter, and for quite a while there was a great deal of discussion on the matter. The Student Councils finally proposed what they thought would be a solution to the problem.

There are many things, that under the present system, seem to be unsatisfactory, and which tend to cause the situation mentioned at the beginning of this article. The ordinary freshman has some idea before entering Yale what course of study he would desire. At least, he has when he enters other universities, so it is only right to suppose that the same holds here. During his first year he is permitted to choose his course of study with little bearing on his future pursuits. Fresh from prep school or high school, he is looking for new ideas and new thought, so he shuns the more practical studies as mathematics or chemistry. This is only natural, as few freshmen look far enough into the future to see that such decisions will make it rather difficult for them to pursue a scientific training. During their first year some of the new courses open up new thoughts and ideas for him. To think is a new experience, and the freshman is swept off his feet so that if he had been looking toward a scientific education when he entered, he has now changed his mind and is ready to sign up for three years of arts or what not? There are other influences at work also, such as his proximity to the college, the physical attractiveness of the college as compared to the Sheff. that the freshman sees, the older traditions and social system of the college, and others which are brought out in the report of the Councils. These, however, cannot quickly be changed, so only a gradual readjustment can be expected there.

This all points to the fact that freshmen are unjustly influenced, not by any particular person or group, but by natural circumstances unavoidable under the present system, to pick a course of study other than the one that will fit them for the business they wish to follow, or for which their former records and experience show they are best fitted.

The controlling factor that has caused such a marked difference in the numbers in the two schools, however, is the nearly constant ratio between those students attending eastern universities who desire a so-called liberal education and those desiring a scientific education. Since the removal of the select course the division has been in the proportion of approximately three to five, so that, with the reducing of the other factors to a minimum, it would seem that the present class would split, 500 men going to the college and 300 to Sheff. With the entrants limited to 850, it is obvious that the present maladjustment is permanent.

If the men were required to designate their preference before being admitted to the freshman year and were required, with a few exceptions, to live up to this choice, the situation could be remedied. Yale College could determine how many students they could accommodate and take that number from those passing the entrance requirements, and Sheff. could do likewise. This does not mean that Sheff. will immediately, or, for that matter, ever have all the men she can handle; but, of the 1,500 applicants, it does seem that there will be more than 250 of the approximate 500 which is her share by the ratio, who can successfully pass the college entrance requirements. Some think that this plan would lower the scholastic standing of the Sheff. men, but though there may be a slight difference between the average of those accepted by the College and those by Sheff. the latter must pass the regular entrance requirements, and that, it would seem, insures a sufficiently high standard. Moreover, it would mean that the courses of study for these men could be more intelligently supervised so that they would be better fitted to continue the course of study which they would have chosen. This more intelligent supervision in freshman year, coupled with the fact that one of the greatest plants of scientific education in the country, would be better able to fill the increasing demand for education and not stand partially idle while the youth of the country are turned away because of the establishment of an arbitrary figure will most certainly outweigh any of the objections that might be raised. That is, the abolition of the deferred choice, and the maintenance of a common freshman year.

J. O. F., '27 S.

THE PHYSICS COURSE FROM AN UNDERGRADUATE VIEWPOINT.

Editor Yale Engineering Notes:

The past five years have called down a great deal of criticism on the course in Physics administered by that department to students electing General Science in the Sheffield Scientific School. Perhaps this is just, or it may be that an hereditary complex has just been developed by men taking this course, and that this has been deployed to incoming classes. Suffice it to say that a deplorable situation has arisen and a wholesale and caustic censure is in vogue. Efforts have been made, both by the department and by the school authorities, to effect changes and to mitigate, if possible, this growing aversion to such a necessary science.

The dual purpose of any natural science, to increase one's store of knowledge and to promote orderly and exact reasoning, is of infinite benefit to anyone. Physics embodies these two aims to the highest degree, and therefore justifies its existence as a scholastic requirement in preparation for any field of endeavor. And so flaws in the method of presentation may be vital blows to the welfare, success, and popularity of the course. With this in mind, let us presume to examine the personnel, inclination toward teaching, and ability of the department, from a purely neutral standpoint. We see opportunities for research beckoning to those who wish to delve deep—opportunities which coupled with the prestige and renown of the University open up avenues to success, yet are not without restrictions in the form of certain minimum teaching requirements. As a result men wishing to do research work may be inclined to regard daily instruction in fundamentals as a necessary evil and to take over no more than the minimum amount of such work. An attitude of this sort is detrimental to the quality of instruction, and tends to be transferred to the student. He in turn, loses interest, and only wants to learn enough formulae and general principles to pass the final examinations. The course thus becomes mere rot.

Another difficulty which has been encountered, arising perhaps to a small degree from the attitude of the instructor, is what the writer (for want of a better phrase) calls an hereditary complex. Let us suppose, for example, that due to some cause the daily recitation has become distasteful:—the average man will say that he is deriving no benefit from the course—that it is too theoretical—that he cannot pass it. Such observations are echoed by others who perhaps are having difficulties with the subject; some men even repeat these remarks because everyone else is saying them, though they themselves are doing very good work. Soon this idea has pervaded the whole class, until a complex is developed by the majority of men—they are firmly convinced that the case is a hopeless one—that only good fortune or Rosies can turn the tide. The impression spreads not only throughout the School, but over the University as well, until individuals not directly concerned take up the cudgel and talk disparingly of the course.

Lest it be thought that the Physics department had failed in its efforts to better conditions, consideration must be given to the manner in which it has attacked the problem. When the criticism began the method of teaching consisted of recitation by small sections, to an instructor, three times a week, supplemented by a two-hour laboratory period and separate computation of the same duration. This was not only irksome, but deprecatory to the course in that it meant a total of eight hours a week spent on a subject which required so *much* exact thinking. A change was realized when lectures were substituted for the recitations, while a weekly test was injected with the laboratory and computation periods remaining unaltered. This rather hurt than bettered the situation, because it invited neglecting the daily work—cramming for the weekly test, which came on Monday, was inclined after the week-end, to be of a somewhat temporary nature, and the final examination proved a rude awakening to many who had slumbered in an atmosphere of pseudo-security. In the present year further changes were made to bring back the daily tests and reduce the computation period. These have both helped considerably.

R. B. C., '28S.

FROM THE ALUMNI WEEKLY.

[EDITOR'S NOTE: The following article may have escaped the notice of many when it appeared in *The Yale Alumni Weekly*, April 15, 1927. It is too good to miss. To any who have read it we recommend a re-reading. We feel that Mr. Cheney is absolutely right when he says character should be an important factor in the selection of entering students. Mr. Cheney is a member of the Yale Engineering Association.]

Sir:—Yale, Mother of men, is, and has been, for a generation a boast which the alumni like to think well founded. The honor of entering the portals of Yale is one so much sought after that at the present time three out of every four men seeking that honor have to be refused—from the college point of view perhaps an enviable situation, but one carrying with it very grave responsibility. Only one man out of four can be given the opportunity of claiming Yale as their Mother! This is hardly race suicide, but it would seem to be a rather far-reaching experiment in eugenics, and it becomes incumbent upon Yale to think seriously whether the men whom she selects for entrance are the best men among the applicants, and consider what is the type of man she is most anxious to graduate.

The writer believes that most Yale graduates hope that their College will turn out the greatest possible number of leaders; leaders in learning, yes, but first of all men and leaders of men! And it behooves us to consider carefully what the qualities are that make leaders, and whether our present method of selection is the one best fitted to secure the men best adapted to the needs of the country.

One hears the boast made with a good deal of private satisfaction on the part of the Faculty that no man can enter Yale with a condition. What is a "condition," and how much does it really gauge a man's value? It is the general custom of colleges to select their pupils by written examinations, as to how much ground they have covered in books and how much they have remembered; the one who has covered the greatest amount of ground in the least time, and has remembered the most, being judged the highest. Is Yale to be a training station for race horses?

Memory is a very valuable quality; speed is also a very valuable quality, but are either memory or speed the most valuable qualities of men? A small boy once asked by his teacher to define the difference between a learned man and an intelligent man said that "a learned man thought the thinks of the other thinkers, but an intelligent man thought his own thinks." How much does our system of selection enable us to determine whether the pupils have or have not the ability of independent thought? The qualities of reason and of learning are two quite different and independent powers and some have even claimed that a very large development in one weakened development in the other; but it is quite certain that the accumulation of knowledge, although a valuable asset to each and every one of us, cannot take the place of ability to reason. In the opinion of the writer, the quality of reason is far more valuable than the quality of learning, but that the two combined are of much greater value than either one separately. There is room in the world for only a limited number of scholars, and each of us can call to mind a number of stupid, learned men, men with encyclopedic minds, who do not know how to use their knowledge.

What other qualities are most needed for the leaders of our country, and what we would most like to see brought out in the graduates of Yale? Almost any man would put first and foremost, Character. Character is, of course, built up of many factors, of which learning is perhaps a comparatively small factor. Idealism, honesty, uprightness, patience, endurance, industry, are all qualities which go to make up a man. Should these things be given no weight, when we come to select the men who are to be granted the privilege of Yale's parenthood? All trees do not grow at the same speed; note the difference between the pine and the oak. Yet the slow-growing tree is usually the strongest. All horses are not race-horses, but the race-horse will not pull the heaviest load—no more do all boys develop at the same rate of speed, or do they learn with equal facility.

What man, given the right to select from a group of men one man for a responsible position, would choose the most rapid one in preference to the surest one? Colleges and schools very frequently in marking examinations give a certain definite length of time in which to perform the task, and a failure to do the full amount of work within the time specified is considered the exact equivalent of doing the whole work with errors counted equal to uncompleted work; no employer would ever measure on this basis.

Yale is perhaps turning from her doors today men whom she will regret hereafter she failed to keep, because they did not measure on the single scale applied.

This new condition makes it imperative that we should give careful consideration to these questions, and to how we shall select men in the future who are to be granted these privileges.

The writer believes that all of the following factors should be considered and given weight in selecting applicants for admission:

1. Learning or scholastic progress. (Speed and accuracy measured separately).
2. Imagination—the power to see.
3. Ability to reason or independent thought.
4. Character, patience, perseverance, honesty, etc.
5. Physical condition, or ability and likelihood of carrying on.

If others agree with the writer that the present system does not form the best possible criterion, and if the other factors mentioned have weight and should be measured, means can be found to accomplish the result.

There is already evidence that other colleges are giving consideration to this subject, and that they are not satisfied that written examinations of scholastic progress should be the criterion. Within a week, the writer received a query from Princeton as to the character and qualifications of an applicant to that institution. Columbia has attempted to measure the reasoning qualities. Dartmouth has its Alumni Board. Yale's problem is more acute than any of these. It is time that we were about its solution. The tendency of man is to follow the line of least resistance, but it is seldom that the line of least resistance leads to the highest goal.

HORACE B. CHENEY, '90 S.

LABORATORY NOTES

(*Continued from page 30*)

CHEMISTRY

Co-operation of Chemistry and Medicine Planned.

Yale is attempting to raise sufficient funds to carry on a systematic chemotherapeutic study. This study is of basic importance today, when Europe is so far ahead of the United States because of better facilities, and because of greater public interest and private endowment for its study.

The purpose of this work is to further unite chemistry and medicine, that is, to approach medical problems from the chemical standpoint. The reaction of human beings to various chemicals and other such problems are to be further studied. Such problems, which are many and far-reaching, cannot be solved without the co-operation of the chemist, who studies the chemical constitution of the substances, and the medical clinic, where their harm or benefit to the individual are studied.

CIVIL ENGINEERING.

Mr Ferry.

Mr. Ferry was graduated from the Sheffield Scientific School of Yale University in 1871. In 1891 he received the degree of Civil Engineer. He entered the office of the City Engineer of New Haven, Conn., on graduation, and took part in surveying and mapping the city. He was promoted to take charge of sewer construction and all work in connection with stone arches and bridge abutments.

He then entered private practice and was connected with the details of the waterworks system of New Haven. He was at one time President of the Connecticut Society of Civil Engineers and contributed many treatises to its publications.

In 1916, he presented a paper entitled "The Yale Bowl" before the American Society of Civil Engineers. Beside designing the Yale Bowl, Mr. Ferry was Resident Engineer during its construction. He died July 31, 1924.

Building Construction Course Popular.

With its enrollment steadily increasing, the Building Construction course is becoming one of the most popular electives in Sheff. The number of men has risen from 7, in the class of 1925, the first year of its existence, to 23 in the present Senior Class.

The course was created by Professor Crane to give students desiring to enter the building construction field a broader knowledge than could be obtained in the straight Civil Engineering course. With this end in view, Prof. Crane has required his men to study such courses as Business Law, Specifications, and Contracts, so that they will be fitted to deal with some of the non-technical problems that come up before contractors and other building constructors.

Prof. Crane is in close contact with leading architects, engineers and builders, and can impart to his students information concerning the latest methods of handling materials. This also helps in placing many of the members of the course after graduation.

As an example of the most recent advances in building construction methods and designing it is pointed out that the building of a house as beautiful as one constructed in 1913 costs only one and one-third as much as it did then, although the index number for building and designing costs based on the year 1913 is 212.

GEOLOGY.

results to appear as publications of the Connecticut Geological Survey.

Dr. R. F. Flint will spend this summer on a survey of the glacial deposits of Connecticut.

Yale Professor Returns from Hawaii.

Prof. H. E. Gregory is paying a short visit to this country to complete some field work in Utah. His work is primarily in Hawaii, where he is directing

(*Continued on page 42*)

SKIN GRAFTING AN UNDEVELOPED SCIENCE

(Continued from page 14)

satisfactorily. Although part of the graft will sometimes slough, in most cases enough will remain to satisfactorily cover the surface. The Ollier-Thiersch graft can be placed on granulations, but usually does not take as readily.

In some cases where scar tissue is excised and Ollier-Thiersch grafts are used to cover the excised area one often meets with discouragement due to the recurrence of scar tissue beneath and in the graft itself. A case in point was a boy who had been severely burned about the lower face, neck and shoulders. The chin was flexed upon the chest and held by strong bands of scar tissue. An attempt was made to excise the scar, releasing the head, and planting Ollier-Thiersch grafts in the area. Although the grafts took well and grew beautifully after four or five months the scar tissue had grown back so extensively that the grafting had been practically useless. This objection was brought up shortly after the method had been reported in the early seventies.

The Wolfe-Krause Method.

Another method of grafting skin was first described by Wolfe of Glasgow in 1875, shortly after the original work of Ollier, Thiersch and Reverdin. He reported the use of full thickness areas of skin denuded as much as possible of subcutaneous fat. Wolfe was interested in ophthalmology and used this type in the repair of an eyelid. Shortly after the report of this case Krause published twenty-one cases of full thickness grafts with successful results. This method has likewise been generally accepted, but probably not as widely as the two types previously described.

The procedure is not difficult. The area to be grafted is measured and a suitable point is chosen on the body for taking the graft. Probably the best place for work on the face is on the medial upper aspect of the thigh. Here the texture of the skin more closely resembles that of the face. The desired amount is measured and excised with subcutaneous (beneath the inner lay of the skin) fat. Taking the graft in the hand it is then denuded of subcutaneous fat as far as possible. The graft is then sutured into the defect with end-on mattress sutures, care being taken to get accurate approximation of skin edges. This is then covered with one layer of vaseline gauze and sea sponges, exerting gentle pressure. This type of graft is used most often in areas about the face and neck, where there are contractures due to scars caused by accidents or burns.

The Pedicled Flap.

This method is usually not included in a discussion of those previously described. The former grafts are all cut free from the circulation. In the pedicle flap the skin is never completely severed from the circulation. The method has been in use from antiquity, the first reports coming from India—later from Italy. These attempts were all plastic work on the nose. The method is used widely and probably with more success than any other method.

The procedure usually requires several small operations. A tube is first raised resembling a satchel handle. At one end an area to be transplanted is excised in several steps gradually diverting the circulation via the satchel handle. Finally the skin to be transplanted is dissected free, the area to be grafted is excised so that there is a fresh surface and the flap is sutured into place, great care being taken to approximate the skin edges well. A dressing of vaseline gauze and sea sponges is then applied. After twelve to fourteen days the satchel handle is cut and fitted wherever it can be utilized. By that time the flap has established direct circulation with the underlying tissue.

(Continued on page 46)

DINOSAUR FOOTPRINTS FOUND IN CONN.

(*Continued from page 22*)

125 million years ago, and is supposed to have lasted about 25 million years. It was long before the Ice Age, and before the White Mountains were uplifted.

What killed these huge animals has always been a point of great interest. It has been the general opinion that some climatic change killed them off, and the fact that there was a lot of volcanic action on the earth contemporaneous with the period of their existence is the basis for a theory that volcanic gases may have exterminated them.

Along with this dinosaur imprint Prof. Chester R. Longwell discovered a large number of fresh water fish below the tracks in darker material.

LABORATORY NOTES

(*Continued from page 39*)

GEOLOGY.

the field work in the Pacific carried on by the Bishop Museum of Honolulu.

West is Field for Research.

Prof. A. Knopf is completing the results of field work in Nevada, which will be published in the bulletin of the United States Geological Survey.

Prof. C. O. Dunbar is engaged in the study of fossil collections that he made during the past season.

Circus Rhinoceros Mounted in Peabody Museum.

The Zoölogical Department has recently completed the mounting of "Big Bill," the famous Indian rhinoceros, which travelled with Barnum and Bailey's Circus for so many years. The department has also obtained from Barnum and Bailey a zebra and a camel, which will be mounted this summer. Three new elephant models are to be added to the case of proboscidean models. With these new mountings the collection of seven models illustrating proboscidean development will be complete. A model of the sperm whale is to be installed to go with the already mounted specimen of the Wright whale. The Peabody Museum, for many years, has been the recipient of the generous gifts of specimens from the Barnum and Bailey's Circus.

Australian Geologist Lectures.

A series of important lectures on geology are being given this spring by Professor Ernest Clayton Andrews, Australian geologist, who was until recently the secretary of the Australian Association for the Advancement of Science. Mr. Andrews has specialized particularly in the mineral deposits of the celebrated Broken Hill district and the Cobar region. He has also carried on important studies in other countries and has devoted much time to a study of the Pacific area, a field which is considered by scientists to be of greatest importance. His lectures here are devoted especially to the Pacific area.

MATHEMATICS.

lished in the American Journal of Mathematics and the Transactions of the American Mathematical Society.

Dr. H. M. Gehman, formerly National Research Fellow, has to his credit a long list of papers on analysis situs.

Prof. E. J. Miles and Mr. Rawles have been working in the Calculus of Variations. Also Mr. Van B. Teach has been developing a new treatment for the parametric problems in the Calculus of Variations.

Prof. J. K. Whittemore continues working on differential geometry.

Yale Represented at Meeting of American Mathematics Society.

The meeting of the American Mathematical Society, held in New York on May 7th, was attended by Prof. James Pierpont, Prof. J. I. Tracy, Mr. J. H. Neeley, Dr. L. T. Moore, Dr. H. M. Gehman and Prof. J. K. Whittemore. Papers were read by Prof. Pierpont, Dr. Moore and Mr. Neelley.

Instructor Goes to Carnegie Tech.

Mr. J. H. Neelley has recently resigned to take an associate professorship at the Carnegie Institute of Technology.

Instructor Honored.

Mr. Van B. Teach, instructor in mathematics, has been appointed to a Sterling Senior Fellowship in the Graduate School.

Text-book Being Revised.

Prof. P. F. Smith is at present revising the text-book on analytic geometry by Smith and Gale.

Papers on Pure and Applied Mathematics.

Dr. L. S. Hill has contributed papers in pure and applied mathematics, publishing in the *American Journal of Mathematics* and in *Telegraph and Telephone Age*.

Dr. L. S. Hill had a paper on Pure Analysis accepted for publication in February by the *American Journal of Mathematics* of Johns Hopkins University.

LABORATORY NOTES
(Continued)

MECHANICAL ENGINEERING.

to roll down a known slope at various speeds. Prof. Lockwood has chosen Mt. Shelburn on the Mohawk Trail, just outside Greenfield, for his tests. Knowing the resistant friction of the car and tires (obtained previously on the rear-wheel dynomater in Mason Laboratory), as well as the weight of the car and slope of the hill, he hopes to obtain a much more exact understanding of the actual resistance of the air on a moving automobile.

Prof. Wohlenberg to Speak.

Prof. Wohlenberg is to present a paper before the Tri-State meeting of the A. S. M. E. in Erie City, Pa., on the third of June. His subject is "Some Fundamental Considerations in the Design of Boiler Furnaces," the data for which was compiled by himself and Mr. F. W. Brooks. Members from Pittsburgh, Cleveland, Buffalo and Erie will be present.

Dr. E. A. Sperry to Lecture at Senior Seminar.

Dr. E. A. Sperry, noted engineer, will speak before the Senior seminar group this month, probably on some phase of the application of the gyroscope to navigation. Dr. Sperry attained the highest honors in the mechanical engineering field in December, 1926, when he was awarded the John Fritz medal.

Annual Machine Tool Exhibition to be Held in September.

The Seventh Annual Machine Tool Exhibition will be held at the Mason Laboratory of Mechanical Engineering on September 6th, 7th, 8th and 9th.

Founded in 1921, as an outgrowth of an exhibition before undergraduates in engineering at Yale, the Machine Tool Exhibition is now an affair of importance to engineers and manufacturers. It is sponsored by the New Haven Section of the American Society of Mechanical Engineers, the Department of Mechanical Engineering of the Sheffield Scientific School, and the New Haven Chamber of Commerce.

DISCHARGE IN RAREFIED GASES

(*Continued from page 10*)

entered. There are thus two different abnormal conditions of the atom which may give rise to the same kind of radiation.

Let us now examine the following new facts in the light of these hypotheses. It was found under special circumstances if the striae in the tube were pink with a given discharge current passing that without changing the gas pressure the striae would change into more closely packed blue striae when the current was increased. Moreover the voltage drop between the blue striae was found to be much smaller than was the case for the pink striae. Since an excited atom must acquire more energy from the electron, which excited it in order that it may radiate blue light, than is necessary to enable it to radiate red light, and since less energy was available when the striae were blue than when they were pink, it is highly probable that the radiation causing the difference of color did not come from excited atoms or molecules and that it must therefore have come from ionized atoms or molecules. Thus after starting out by measuring the distance between striae we have ended with evidence regarding an intra-atomic process involved in radiation.

AMERICA'S LONGEST TUNNEL

(*Continued from page 8*)

forward end, and the whole machine rides on two pair of steel dollies running on tracks along the bench, so that as soon as from 15 to 20 feet of bench has been excavated beneath the rear of the girder and the posts have been put in, the crossarms can be drawn in and the machine moved ahead to another set-up.

Alignment surveys for the tunnel were handicapped by severe climatic conditions and by the refraction occurring between altitudes 12,000 and 9,100, which necessitated working at night with lights. A line was run over the Continental Divide between portals and sights established beyond East and West Portals, so that by setting up a transit on one of these sights and backsighting on a monument on the divide several miles away, the line could be plunged into the portal and thence carried under ground by repeated sights on six-inch Vernier bars rigidly suspended from the roof of the Water Tunnel. The length of the line was determined by triangulation, U. S. Government Invar tapes having a very low coefficient of expansion being used for the measurement of the base line. Grades were carried over the pass by precise levels along the center line clearing and checking by line carried over the railroad tracks. The headings met within .11 feet when holed through, and were off only .3 of a foot on grade—a closure of 1/230000.

There now remains less than 600 feet of railroad main headings to be driven and less than 4,300 feet of enlargement to be done in the railroad tunnel before it will be ready for trains. When the first Denver & Salt Lake train christens the tunnel this year it will mean the unlocking of the latent resources of Northwestern Colorado and the overcoming of a great natural barrier that will no longer interfere with transcontinental traffic.

RICHARD SWANN LULL

(*Continued from page 29*)

The answer would surely include every quality Dr. Lull has. Integrity, Genuineness, Wholesomeness, and all the rest. They have been summed up admirably in Dr. Lull. He remains gentleman, scholar, and sturdy pioneer—a lasting personality.

R. B. M.

[*This is the first of a series of character sketches of outstanding teachers and graduates to appear in each issue of* THE YALE SCIENTIFIC MAGAZINE.]

SEISMOGRAPH INSTALLED IN MUSEUM

(*Continued from page 14*)

seismograph will throw the needle entirely off the drum.

Records of shocks are taken as follows: The drums revolve once every hour, and the smoked paper on the drum is marked off into spaces for each minute. As the drums revolve, the needles trace vibrations on the paper. The paper for one day is taken off the drum, and washed in a bath of shellac and alcohol to preserve the smoked surface. Blue prints are occasionally made from the smoked papers and exhibited with the seismograph. The magnitude of the shocks recorded is determined by the size of the vibrations. The directions of the shocks and their distance from the seismograph is found by comparing the vibrations on the cards for each unit. Since the drums are at right angles to each other, a shock will be recorded more strongly by one needle than the other, according to its direction from the instrument. The comparative size of the synchronous vibrations on the drums, therefore, tells in which direction the quake occurred, and how far away it was.

There has been constructed in the Museum a fulcrum pendulum, which will be installed there. This instrument consists of a sixty-pound ball suspended by a .090 inch wire from a yoke supported by a hard pivot resting in an equally hard cup. The yoke is balanced by adjusting a movable weight, and can not be thrown off balance after being adjusted. The pendulum, which will be used to illustrate that the earth revolves, will swing over a dial on a table on the ground floor of the museum. The dial is to be marked off in 15 degree intervals, the intervals being numbered 1, 2, 3, 4, 5, etc., around the circumference. To prove that the earth revolves the pendulum is started swinging in a North-South plane in the morning. Examination of the dial each successive hour thereafter will show that the plane of the pendulum's arc is 15 degrees farther from the original North-South plane. Thus by evening, when the inertia of the pendulum no longer keeps it swinging, its arc will be shown on the dial to be in the East-West plane, thus proving that the earth revolves.

SKIN GRAFTING AN UNDEVELOPED SCIENCE

(*Continued from page 41*)

Flaps are used quite commonly in repairing cicatrical contractures of the neck and upper thorax anteriorly. In these cases they are best thrown over the shoulders from the back. Flaps can be used to cover excised areas where thickness of skin and subcutaneous tissue is required in such cases as following excision of X-ray burns on the feet or hands. In the former flaps can be taken from the opposite leg or thigh and inserted into the excised area on the opposite limb. The extremities can be held in position by a plaster cast or splints. Flaps are best transferred to the fingers from the anterior surface of the chest. In plastic work as it is more often necessary to transfer a flap to obtain a good result. This can be best accomplished by the transfer of grafts from the forehead as the hair can be used to cover the unavoidable scar. Sometimes when this cannot be accomplished a pedicle flap can be transferred from the thorax to the hand and then to the nose.

These are the methods commonly employed in the grafting of skin. The grafts which we have described are autografts when skin is taken from the same individual. Grafts taken from others have been found to take successfully in a certain number of cases, however, in the majority of instances such grafts either do not take satisfactorialy or retrogress after three or four weeks. The explanation of this remains obscure. It was thought that grafts might depend on the compatibility of the blood, but this has not been found to be true.

"What's the future with a large organization?" That is what college men want to know, first of all. The question is best answered by the accomplishments of others with similar training and like opportunities. This is one of a series of advertisements portraying the progress at Westinghouse of college graduates, off the campus some five—eight—ten years.

Frenger Came Here to Sell

R. F. FRENGER

WHEN R. F. Frenger was at New Mexico State, in 1915, automatic control for sub-stations, hydro-electric generating plants, railway and mine sub-station systems, was a hazy dream. Even five years later, when Frenger was working in the Switchgear Sales Section of the Westinghouse Company, automatic switching was far, far away.

Today, however, Frenger, still in his thirties, finds himself in effect the Sales Manager of an automatic switching business — a business that runs up into seven figures every year.

Frenger came to Westinghouse to sell. He expected to sell steam apparatus, since he had taken an M. E. degree.

After a period in the Westinghouse sales school, he became interested in switching apparatus. He spent months on the engineering side of the work. He spent several years as a sales specialist in the Westinghouse Chicago Office.

Then, as automatic switching grew in importance, Frenger grew along with it. Today he is head of the Automatic Switching Section of the Switchgear Sales Department.

Frenger's work is pioneering in a very real sense, for the automatic control business, lusty as it is, still is in its infancy. Engineering ways and means must be supplied as well as specialized sales skill. The whole world is the market.

Not long ago Frenger ran out to San Antonio to help the local Westinghouse salesman land an order that puts the San Antonio sub-stations under automatic control. When the Holland vehicular tunnel opens, and connects Manhattan with the Jersey shore, Frenger can point to the traffic signaling system as coming from his section.

At Cleveland one man in a downtown office building turns off and on eleven different sub-stations scattered throughout the city and its suburbs to operate the railway system — all without leaving his chair. Frenger's section again.

It is another case of a well trained man in a pioneering organization.

Westinghouse

THE YALE SCIENTIFIC MAGAZINE

VOL. II NOVEMBER, 1927 No. 1

The Physiological Aspect of Athletics
PROF. H. W. HAGGARD, 1914S

Next Great Revolution Will Be Biological
ELLSWORTH HUNTINGTON

Metal Structure Revealed by New Methods
PROF. C. H. MATHEWSON, 1902S

Science Helps Develop an Emotional Art
SYDNEY K. WOLF

PUBLISHED QUARTERLY IN THE INTERESTS OF SCIENCE AND ENGINEERING IN THE SHEFFIELD SCIENTIFIC SCHOOL

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This familiar mark appears on many electrical products, including motors that drive time- and labor-saving office machines.

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• • •

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• • •

Here's a statistical job. The reports are in; thousands of figures to analyze. Looks like overtime for fifty clerks. "Certainly not," answers electricity, as a button starts the motor-driven sorters and tabulators. Key cards are punched with lightning fingers. Electric sorters devour 24,000 cards an hour. Tabulators add quantities and amounts in jig time, and print the totals.

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Go to almost any bank today. Hand in your account book. Click, click, click, goes the electric book-keeping machine and back comes the book to you. Five operations performed in that brief moment. Everybody saves time, —you, the clerk, the bank,—when electricity is the book-keeper.

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In the office of to-morrow you will find "electrical fingers" doing more work than even to-day.

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AS indicative of the service rendered by The Foundation Company over this period of years, these partial lists of repeat contracts have special significance. In one case no less than thirty contracts have been awarded by one owner.

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THE YALE SCIENTIFIC MAGAZINE

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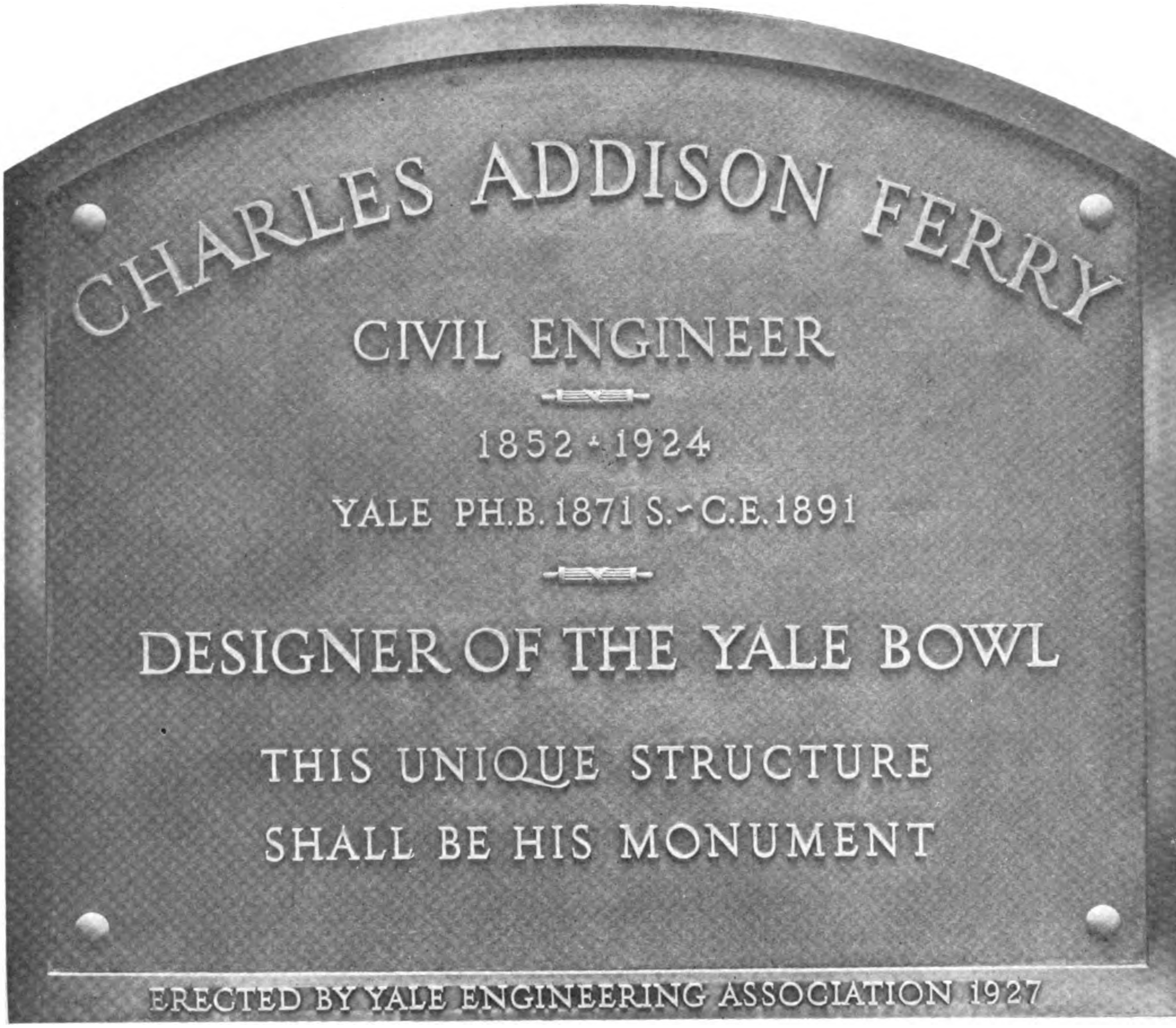
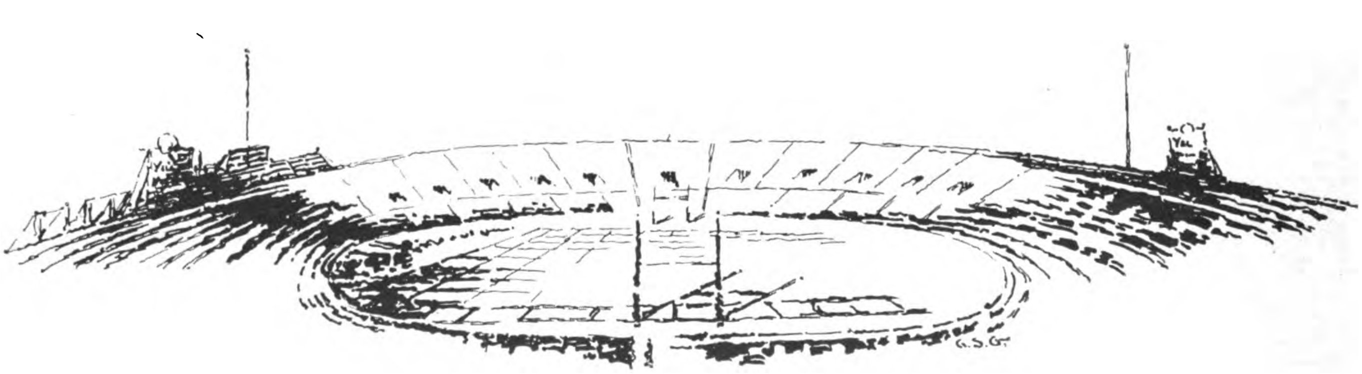

CHARLES ADDISON FERRY
CIVIL ENGINEER
1852 - 1924
YALE PH.B. 1871 S. - C.E. 1891
DESIGNER OF THE YALE BOWL
THIS UNIQUE STRUCTURE
SHALL BE HIS MONUMENT
ERECTED BY YALE ENGINEERING ASSOCIATION 1927



The Physiological Aspect of Athletics

Experiments Show That Oxygen Debt and Pulse Rate are Determining Factors in Limitation of an Athlete's Exertion

By PROF. H. W. HAGGARD, 1914S

Why is one man an athlete and another not, although with seeming equal physique. The question has always been the subject of popular speculation. Dr. Haggard, however, has gone into the problem in a scientific way and here presents the results of his experiments on one phase of it—endurance.

THE skill, power, and endurance of the athlete are physiological qualities. Skill is dependent upon the organization and development of the nervous system; it has an analogy in music. Skill in the playing of an instrument can be developed by training; anyone can be taught to make a sound come out of a horn—and many do—but no amount of training alone will produce a musician. Likewise if the athlete is to rise above mediocrity he must have an inborn quality of his nervous system that will allow him to develop, under training, a control and coordination of his muscular system better than the average. One aspect of skill is the economical use of power so that the largest possible amount of the total energy expended is delivered to the task attempted. Another aspect of skill, and one in which it rises above the almost automatic control of the muscles which training and practice develop, is the application of judgment to the endeavor; the skilled runner chooses the pace at which he can give all he has to the race but at which he does not give it all short of the finish line.

For power and endurance the analogy with musical training ceases—these two qualities are not appreciated in musicians. Power has a counterpart in mechanical devices, of which the automobile furnishes an example. In the hands of drivers of equal skill, the car which delivers for its weight the most power to its rear wheels finishes the hill climb first; with equal skill of performance, the oarsmen who apply the most power to the oars of their shell win the race. An analogy for endurance is difficult to make. The term is applied to the automobile, but there it means the material endurance of the tires and engine. The athlete does not wear himself out in the race; his endurance is functional rather than material. Comparison might be made with distance flights in the aeroplanes; endurance would be the miles covered with the maximum load of fuel and oil which the plane could carry. The plane is not worn out by the flight; it merely needs to be refueled—the recovery process in the body—in order to continue its flight. The physiological factor in athletics with which this paper is primarily concerned is that of endurance.

Length of Time an Exertion Can Be Maintained.

The length of time a certain exertion can be maintained is the factor which determines how fast a man can run or a crew can row over a given distance. The maximum speed at which a distance can be covered is known to vary with the distance; the mile race is run at only about sixty per cent the speed at which the one hundred yard dash is run. The endurance of a man varies with the rate at which he does work, but the variation is not one of direct proportion. As the intensity of the work rises the time during which it can be continued is more than proportionately shortened.

The statement is commonly made that for a ten-hour day a man can sustain work at the rate of 0.1 horse power. At first glance that does not seem like much work, but a little calculation will show that it is considerable. When a man does work only a portion of the energy which he liberates is in the form of the work; by far the greater part of the energy is in the form of heat. The same is true also with other prime movers such as the gas engine and the steam engine; only a fraction of the energy contained in the gasoline and coal is recovered as work, the remainder appearing as heat. The efficiency with which a man does work varies with the nature of the act performed and with the skill employed. but for many acts it ranges between 15 and 25 per cent. That is, 15 to 25 per cent of the total energy expended in performing the act is in the form of work and 85 to 75 per cent of the energy expended is in the form of heat. The men of the Yale Crew of three years ago—The Olympic Championship Crew—when tested on a rowing machine in the laboratory developed about 20 per cent total thermal efficiency. Neither a gas engine nor a steam engine can develop this efficiency at the temperature of the body.

To return to the man doing work at the rate of 0.1 horse power for a ten-hour day: With a total thermal efficiency of 15 per cent the man would make an expenditure of energy both as work and as heat equivalent in terms of power to 0.66 horse power—0.10 as work performed and 0.56 as heat wasted. This amount of energy expressed in terms of heat equals 2,122 B.T.U., or 528 large calories each hour; or for the 10 hours of work 21,120 B.T.U., or 5,280 large calories. For purposes of comparison we must add to this total an average energy expenditure for the remaining 14 hours of rest and sleep, 4,000 B.T.U., or 1,000 large calories. The daily expenditure of energy for the man doing work at the rate of 0.1 horse power is thus 25,120 B.T.U., or 6,280 large calories. The daily expenditure of the average Yale student is about 10,000 B.T.U., or 2,250 large calories; that of a man working with a pick and shovel is about 20,000 B.T.U., or 5,000 large calories; and that of a lumberman about 24,000 B.T.U., or 6,000 large calories.

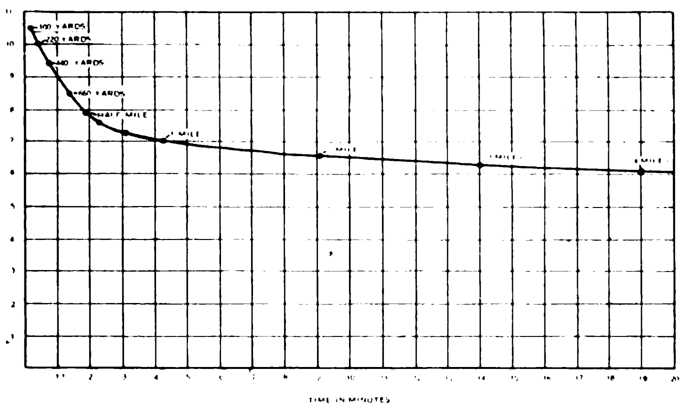
A Classical Example of Heavy Work.

A classical example of heavy work is that of the Egyptian who today, as for centuries, supplies the power to the shadouf or primitive well sweep, used to lift water from the Nile to irrigate the lands at a higher level; he expends 24,000 B.T.U., or 6,000 large calories, calculated at an efficiency of 20 per cent, although he works only six hours each day. From these facts it becomes evident that work at the rate of 0.1 horse power for a ten-hour day is a considerable amount of work—it becomes even more evident when the 25,120 B.T.U., or 6,280 calories are expressed in terms of the amount of food which the man

must eat each day in order to supply this amount of energy. It equals 10.5 quarts of milk or 7 dozen eggs, or, if one wishes to carry it to absurdity, about 140 oranges—a day's work in itself—and is equivalent to the energy in one and a third pints of gasoline. Few men sustain this amount of work and few have corresponding appetites while maintaining a uniform weight. The food equivalent to 6,000 large calories approaches the maximum amount which the alimentary tract can handle each day.

The work on the shadoufs mentioned above is at the rate of 0.13 horse power of external work and is continued to a total of 6 hours a day. Work at the rate of 0.2 horse power is more than is sustained in any occupation other than for brief periods. Most Yale students attempting this amount of work on a stationary bicycle with a Pronay brake on the rear wheel quit willingly after 10 or 15 minutes, while exceptionally vigorous students carry it for an hour or even longer, but are exhausted by it. The bicycle does not permit the use of as many muscles nor their use at as great an efficiency as do some other exertions, particularly walking and running; the work done in running at the rate of 7.5 miles per hour is approximately 0.2 horse power and can be continued for longer than the same work on the bicycle ergometer. The Yale Olympic Crew mentioned developed for the 4-mile race work up to 0.45 horse power and for the 1¼-mile race work up to 0.57 horse power. The man who does the 100-yard dash in about 10 seconds develops for that time nearly 3.0 horse power of external work, but only for the few seconds.

The accompanying diagram shows the speed for some world records in running in relation to the duration of performance; the great shortening of the time as the speed is increased is evident.



Curve showing time and average speed for some world records in running.

One of the factors responsible for the disproportionate shortening of the time of performance with increase of speed is the loss of muscular efficiency at high speeds. Work is required to move the muscles, for they are of viscous consistency and offer resistance to change of shape; this resistance increases as an exponential rather than as a direct function of the speed. The internal work of the muscles usurps an increasing amount of energy which would otherwise be available for external work. At very high speed practically all the work of the muscle is used in merely shortening it and little energy is left for external work. High speeds are therefore wasteful.

Fatigue and Exhaustion.

The limiting factors to exertion are fatigue and exhaustion. These terms cover a variety of conditions which develop under different circumstances. The types of fatigue which concern the athlete are: (1) Fatigue which results in a short time from extremely violent effort; and (2) the fatigue, called exhaustion, which results from an effort of more moderate intensity continued for a long time. Both of these types of fatigue are defined as muscular—but include a nervous element, although their cause and effect are in the muscles used. There is also a third type of fatigue which may be described as resulting from the wear of the body as a whole but not specifically of the muscles; it is soreness, stiffness, sleeplessness, and general lack of inclination for effort. Of these types of fatigue only the first is clearly understood. Its theory is based upon present-day conceptions of the action of muscles.

Yale Olympic Crew of 1924 developed greater thermal efficiency than any engine could at temperature of the body.

Action of Muscles.

A muscle, when stimulated by an impulse sent to it through the nervous system, tends to shorten. The tissue which makes up the muscle may be thought of as assuming a new state of elasticity by virtue of which the muscle pulls upon the structures to which it is attached. If the force opposing the muscle is less than the force imparted by the new state of elasticity the muscle shortens and work is performed. The state of elasticity excited by the nervous impulse is accompanied by the liberation of energy; this energy is obtained by the disintegration of chemical substances—foodstuffs. The muscle liberates energy whether or not it shortens and thus does work; the biceps muscle, when merely held firm, as in showing the size of the muscle, or which pulls against a fixed object, expends energy even though no work is accomplished. An analogy to the dissipation of energy in this static state is found in an electro magnet holding up a mass of iron; the magnet system is mechanically stationary and hence no work is being done, yet energy is continually dissipated from the current of electricity which passes through the wires of the magnet, in this case mostly as heat.

Changes Within the Muscle.

The chemical reactions which occur in the muscle during the stage of contraction, or attempted contraction consist largely in the breaking down of a substance known as glycogen into lactic acid. Glycogen is a form of starch; it is formed in the body from the carbohydrates of the food. When starches or sugar are eaten they are digested into simple sugars and absorbed into the blood surrounding the intestines. All of the blood leaving the intestines goes through the liver. This organ abstracts from the blood reaching it any sugar in excess of 0.1 per cent. The sugar thus removed is converted into glycogen and stored in the liver. If the concentration of sugar in the blood falls below

the normal of 0.1 per cent the deficit is made up by the reconversion of glycogen to sugar and the passage of the sugar into the blood; by this means the concentration of sugar in the blood is held constant. The muscles are also able to store glycogen but to a less extent than the liver. They obtain the sugar from the blood circulating through them. In exceptionally prolonged muscular exertion—the Marathon race—the man may use up all the glycogen stored in his body. Muscular exertion cannot be performed when the sugar is thus depleted and the man collapses. After he is fed sugar or substances digestible into sugar he can continue his effort.

The muscle, during the time it is stimulated by a nervous impulse, breaks down glycogen into lactic acid, but no oxygen is used. The energy of this reaction appears as heat, although not much is developed at this stage, and as the work accomplished by the shortening of the muscle. During its contraction a muscle does not utilize oxygen; the chemical reaction is anaerobic. The store of glycogen is gradually consumed and in its stead lactic acid accumulates.

The second phase of the reaction in the muscle occurs during the period of relaxation. In this stage oxygen is used and most of the heat is developed. One-fifth of the lactic acid which has accumulated during the period of contraction is oxidized; by the energy thus liberated the remaining four-fifths of the lactic acid are reconverted into glycogen and the muscle is, so to speak, recharged for the next contraction. It has lost some of its glycogen which must be made up from sugar obtained from the blood. The oxygen to burn the lactic acid accumulated in the muscle is derived from the blood which circulates through the muscle.

The Oxygen Debt.

The important fact in regard to the chemistry of muscular action is that the muscle can operate for a time without using oxygen. When the supply of oxygen to the muscle is insufficient for its rate of activity the muscle nevertheless continues to work; it accumulates lactic acid which is destroyed later when the supply of oxygen is adequate for that purpose. Under these conditions the muscle is said to go into debt for oxygen. A deficit or debt of oxygen develops in the beginning of all vigorous muscular exertion, for there is a lag in bringing to the muscles, by means of an increased activity of the heart, the supply of oxygen which they need. This oxygen debt is paid up after the exertion is stopped; the continuing rapid rate of the heart and the panting after the exertion are evidences of the paying up process. If it were not for the oxygen debt the beginning of any muscular exertion would be slow and would increase only as the heart responded; there would then be no sudden vigorous effort, such as the hundred yard dash; instead of a quick start the runner would start at a slow walk and accelerate his pace only gradually. As it is in reality the 100 yard dash is run almost entirely on the oxygen debt.

There is a limit to the oxygen debt which can be accumulated by the muscles. When large masses of muscle are used, as in running, this debt amounts to about 15 liters of oxygen for vigorous men but less for most men. When the maximum debt has accumulated muscular action must cease—the runner has to stop until the debt has in part been made up.

Rate at Which Oxygen Is Used.

The amount of oxygen consumed from the air breathed by a man varies directly in proportion to the extent of his exertion; it is the amount of oxygen necessary to burn the lactic acid formed by the action of his muscles. The quantitative relation of the factors involved are as exact as in any other form of chemical reaction. In fact, the rate at which energy is expended by a man is commonly measured by the rate at which he used oxygen. All the data necessary for this determination are obtained from the expired air collected during and for a short time after the exertion. In determining the energy expended by the Yale Crew, as mentioned above, and in estimating their efficiency, the men exhaled through a mouthpiece connected to check valves so that their expired air was collected in a gasometer; measurement and analysis of this air showed the amount of oxygen they consumed, and from this the energy equivalent was calculated.

Oxygen Debt Factor in Limiting Violent Exertion.

For many forms of athletics the oxygen debt, and its maximum of 15 liters is the factor limiting the exertion. Like any other debt the magnitude of that for oxygen depends upon the relative rates of outgo and income. When the rate at which a

Egyptian Shadouf workers are a classical example of heavy work. They expend nearly one and a half times as much energy as the average Yale student.

Photo by Underwood.

man can bring oxygen to his tissues equals the rate at which oxygen is needed the debt does not rise above that incurred at the start of the exertion; but when the amount of oxygen he can bring to his tissues is less than the amount needed, the debt increases. The time the exertion can be continued is then determined by the length of time it takes the debt to accumulate to its maximum.

The greatest rate at which oxygen can be brought to the tissues—the mechanism is discussed below—is for an exceptionally well developed man in the best of physical conditions about four liters of oxygen a minute, but much less for most men. Four liters of oxygen a minute used in the body have as their energy equivalent in heat approximately twenty large calories.

In turn 20 large calories per minute are equivalent to energy of 1.85 horse power; if the man works at a total thermal efficiency of 20 per cent his external work will be slightly less than 0.4 horse power. The amounts of work in some form of athletics is discussed above and, as seen there, many are at much more than this rate. If the man's exertion does not require more oxygen than can be brought to his tissues he can continue the exertion for a comparatively long time—it falls into the flat part of the curve given in the figure.

If, on the other hand, the energy expended during the exertion is at a greater rate than that at which the oxygen can be brought the debt increases. To illustrate the point concretely: A man is running a mile race. This particular man is capable of supplying to his tissues each minute a maximum of three liters of oxygen, but the exertion, for him, necessitates an expenditure of energy equivalent to 6 liters of oxygen. Each minute that he runs the man goes into debt for the difference between this requirement and his oxygen consumption—in this case 3 liters a minute. At the end of 5 minutes his oxygen debt will have reached 15 liters and he will then slacken his speed whether he has reached the mile mark or not. If he is an experienced runner he crosses the mark with very little of his oxygen debt remaining—he has given everything he has to the race. If he is inexperienced he may cross the line with some of his oxygen debt unutilized. In that case he could have gone faster. Or he may accumulate his maximum debt before he reaches the end of the race, and cannot finish or only at a slow pace.

Heart as the Determining Factor in "Wind."

Oxygen is brought to the tissues by the blood. The blood in turn obtains oxygen from the air breathed into the lungs. There the oxygen is combined in a loose chemical form by the blood; when the blood is circulated to the tissues the oxygen is freed and is used by the tissues according to their needs. Blood is capable of carrying about 18 per cent of its volume of oxygen, that is, each 100 c.c. of blood can carry 18 c.c. of oxygen, and on leaving the lungs normally holds this much. As in any transporting system, such as a railroad, the amount of material carried under a uniform load varies with the speed of movement. In the body the movement is given to the flow of blood by the pumping action of the heart.

It is a commonplace observation that the rate at which the heart beats is quickened by exertion. A little calculation will show the need for this. The heart of an average man pumps to his tissues each minute during rest some 6 liters of blood. (This value is subject to much individual variation). This blood contains only 18 per cent by volume of oxygen, or a total of 1,080 c.c. in the 6 liters. The average man at rest uses about 200 c.c. of oxygen a minute and the amount of blood pumped supplies this with the use of only about 20 to 25 per cent of the oxygen in the blood. But suppose this man exercises and in so doing uses 3,240 c.c. of oxygen; even if he uses all there is in the blood, his circulation must rise to 18 liters a minute, for many men it will rise to 30 liters or even more.

The act of breathing can, under almost all circumstances, supply sufficient air to the blood to bring it up to the saturation point of its chemical combination with oxygen. The limiting factor to the rate at which oxygen can be supplied to the tissues is the volume of blood which the heart can pump. The heart is the determining factor in "wind." "Shortness of breath," so-called, is not due to any deficiency of the lungs; it arises from the inability of the heart to keep pace with the rate of energy expenditure so that the tissues do not, for that reason, receive an adequate supply of oxygen. The man with a diseased heart illustrates in an extreme degree the part played by the heart in "wind." Such a man may have good muscles in his legs and good lungs, but he becomes "out of breath" on slight exertion because his heart fails, as a result of its damaged state, to pump blood in proportion to even the slightly increased need for oxygen. If his heart disease becomes very severe he may be "short or breath" even when he is sitting at rest.

Volume of Blood Pumped by the Heart.

It is possible to estimate the amount of blood pumped by the heart by means of a method developed in the laboratory here; it is the so-called ethyl iodide method. In brief, it consists in allowing a man to breathe from a gasometer of air which contains a very low concentration of the vapor of ethyl iodide. This particular substance is rapidly destroyed in the body and hence does not accumulate. The rate at which it is absorbed and the concentration developed in the blood leaving the lungs, as determined by analysis, afford a basis for the calculation of the amount of blood pumped through the lungs each minute. The amount of blood passing through the lungs in a minute is exactly the same as that pumped out by the left side of the heart. No discomfort whatever is experienced by the subject undergoing the determination which is complete in 5 or 10 minutes.

Two years ago fifty men from the student body volunteered as subjects for the determination of their circulation rates; they were tested both at rest and under severe exertion. The points of interest here are the following:

In the men tested while sitting at rest, their hearts pumped from 5 to 12 liters of blood a minute; their oxygen consumption during this time was such that their tissues used only 20 to 25 per cent of the oxygen brought by the blood. The rate at which the heart beat averaged 70 per minute, with the lowest around 40 and the highest around 90 or 95.

Under severe exertion, performed by riding on a bicycle with a Pronay brake on the rear wheel to necessitate work at the rate of 0.22 horse power, the amount of blood pumped by the hearts of the men varied widely. A few men—mostly crew men—pumped as much as 30 to 35 liters a minute; the amounts pumped by some men were as low as 14 to 18 liters per minute. The amount of oxygen used from the blood varied from 40 to 80 per cent of that available; the less used, the better are the tissues able to support their functions. The amount of oxygen used by the men each minute,—the exertion was sufficient to elicit nearly the maximum circulation for each man,—ranged from 2 to 4.0 liters.

In passing from rest to exertion the pulse rates of these men were approximately doubled, although the circulation was in many cases tripled. The point that is important in this connection is that the men who had a rapid pulse at rest, when excitement was eliminated, and hence a high pulse under exercise did not as a rule pump a large quantity of blood during exercise. That is to say, a man who at rest had a pulse of 60 or 70 would have under the exertion a pulse of 120 to 140; at rest his heart might pump 8 liters of blood a minute and under the exercise 24 liters. Another man whose pulse was 90 at rest might pump also 8 liters of blood, but under exertion his pulse would rise to 170 or 180 beats per minute and his circulation would rise only to 16 to 20 liters per minute. It would seem that an excessively rapid rate of heart beat is not compatible with a large circulation under exercise, probably for the reason that the heart does not have time to relax properly between the beats. In one case a graduate student, a former cross country runner, volunteered to ride the bicycle ergometer to exhaustion—

(Continued on page 51)

Power Requirements of Motor Vehicles

Rolling, Air and Grade Resistance Determine Engine Horse Power in Designing Car of Given Weight for Given Speed

By Prof. E. H. Lockwood, '88S

A MOTOR CAR uses more power than a horse-drawn vehicle of the same carrying capacity. The need of increased power by the motor car arises, not from difference of grade or road surface, but from greatly augmented speed made possible by mechanical means. A stage coach using four horses might travel five miles an hour, while an automobile using forty horsepower might travel fifty miles an hour, a ten-fold increase both in power and speed.

There is a natural apprehension that motor car speed brings danger, hence is to be deplored. This fear is only partly justified, since improvements in car design have removed many elements of danger. Some of these improvements are in springs, tires, shock absorbers, etc., which give the smoothness of control needed by the driver at high speeds. Another important element is the use of four-wheel brakes for quick and safe stopping of the rapidly moving car.

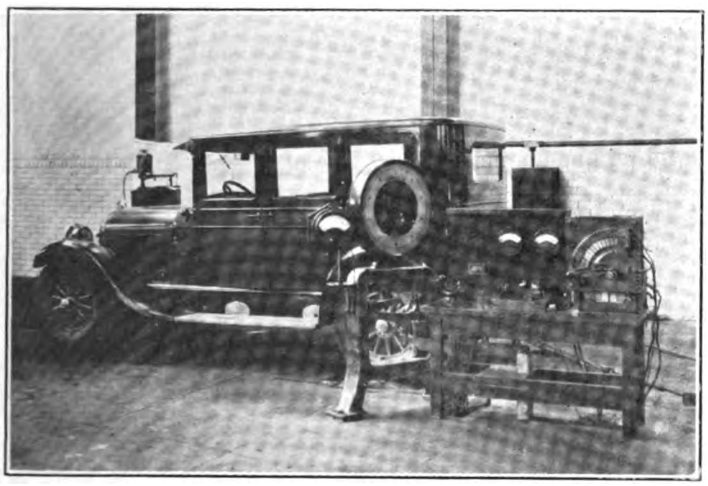


Fig. 3. Test car with rear wheels resting on traction pulleys, and instruments in foreground. Traction pulleys located in basement, are shown in another figure.

Vehicle improvements such as those referred to, coupled with general betterment in highways, have produced a substantial increase in average motor car speed during the past decade. Stated in figures, former car speeds of 30 to 35 miles per hour have increased to perhaps 45 to 50 miles per hour. Such an increase of speed should require by theory doubling of the horsepower, and this has actually occurred as might be expected.

Rolling Resistance.

Friction losses within the vehicle may be classed under tire losses, which make up about one-half the entire loss, and bearing, gear and lubricant losses which make up the remainder. The name rolling resistance is applied to the total friction losses, and forms the starting point in the power requirement of motor vehicles.

Rolling resistance can be measured independently of the air resistance by use of the chassis dynamometer, where, with the car securely anchored, either pair of wheels can be rotated at various road speeds. Such tests, carried on at the Mason Laboratory of Yale University, and other places, have shown that rolling resistance increases slightly with speed of the car, but depends mostly on its weight and can be computed from the latter alone. For a passenger car in good running order, the rolling resistance might be on the average 16 pounds per thousand pounds of car weight at low speeds, increasing to 18 pounds at high speeds. These figures will be greater for a new car with initial stiffness, and will be greater for any car when first started with cold tires and lubricant.

The power that must be provided for rolling resistance of a 3,500 pound car with 700 pounds passenger load, is shown by the curve OA, Figure 1, reaching a maximum value of 16 h.p. at 70 miles per hour. This curve may be considered the power required to propel a car of this weight with a perfect streamline body having zero air resistance.

Pictures of apparatus for measurement of rolling resistance, as installed at Mason Laboratory, are shown in Figures 3 and 4.

Air Resistance.

Assuming the vehicle moving through still air, a resistance will be met depending on the car speed, the frontal area of the body, and to a slight extent on the shape of the body, rounding of corners, etc. Air resistance is determined at present by computation, as direct measurement is quite difficult, although one full-sized wind tunnel large enough for automobiles has been built and used for limited experiments.

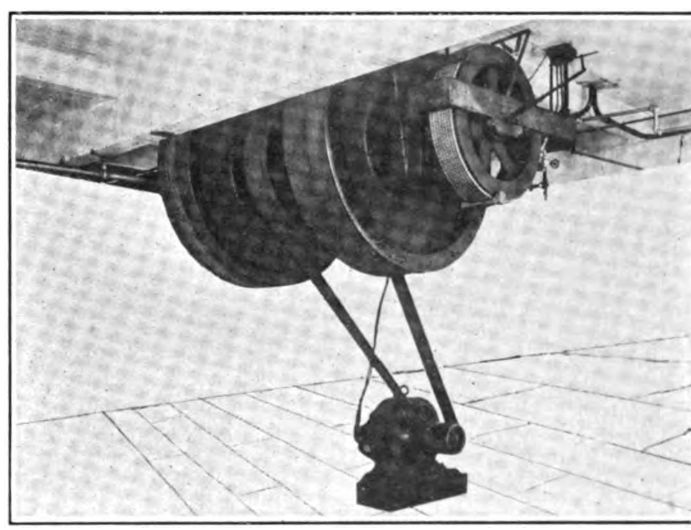


Fig. 4. Traction pulleys, hung from basement ceiling, support car wheels and yield complete power measurement of an automobile.

Air measurements also have been made by placing an automobile on a flat car at the head of a train on a level track. Tests by these methods have been made up to speeds of forty miles per hour. Experiments are in progress at Yale University, in

which the car has been coasted down hill under conditions where air resistance can be measured, at speeds from 50 to 60 miles per hour.

Using the best values for air resistance, a horsepower curve has been computed for a 3,500 pound car with 700 pounds load, shown by the curve OB, Figure 1. The horsepower at 70 miles per hour is shown by MB, made up of air resistance AB of 47 h.p. and rolling resistance of 16 h.p. shown by MA, a total of 63 h.p.

Curve OB, Figure 1, represents only the power required to overcome car friction (rolling resistance) plus air resistance, therefore it may be called the level road power curve. Additional power will be required for ascending grades as considered in the next article. This diagram shows clearly how level road horsepower is used up at high speeds, a small part for car friction and a large part for air resistance.

Grade Resistance.

Power is required to propel a car up hill, in addition to rolling resistance and air resistance. Grade horsepower can be computed quite easily, since the gravity pull on the car can be had from the per cent grade and car weight.

Grade horsepower can be shown in comparison with level road horsepower, by a diagram like Figure 2, where the level road curve OB is same as Figure 1. Grade curves have been drawn paralleling OB, up grade by solid lines, down grade by dotted lines. This diagram gives information about horsepower in a very convenient form. For example, at a speed of 40 miles per hour, 17 h.p. will be required on level, 40 h.p. will be required on 5 per cent grade, 60 h.p. will be required on 10 per cent grade, while zero power will be required on four per cent down grade.

When the down grade curves fall below the zero line, power required to propel the car will be negative, that is, it must be held back by engine or brakes. The point where the down grade curve crosses the zero line indicates the speed at which the car will coast in neutral gear on that grade. The diagram gives complete data on the horsepower required to propel a car, over a considerable range of speeds and grades, assuming a constant load in the car.

Engine Horsepower.

The output of a gasoline engine increases with speed up to a maximum value, depending on the design, after which the power

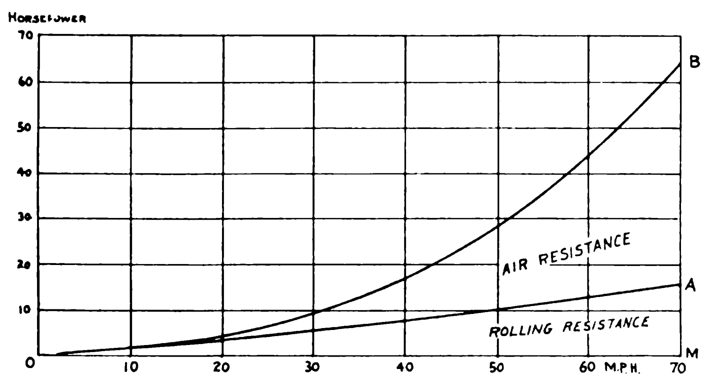


FIG. 1. ROLLING RESISTANCE AND AIR RESISTANCE HORSEPOWER OF 4200 pound Automobile. Curve OB represents total power required on level road.

gradually or rapidly falls off. Low speed engines, such as used in trucks, may reach maximum power at 1,200 to 1,500 r.p.m., while passenger car engines often develop maximum power at 2,500 to 3,000 r.p.m. Whatever the speed of the engine, it can be so geared up that maximum power of the engine can be delivered at a predetermined car speed in miles per hour.

The engine power required by a car depends on car weight and desired speed. The problem can be nicely solved by a diagram such as Figure 2, by reference to the level road curve OB. Taking the average car for which Figure 2 was drawn, the following information can be read directly from the figure.

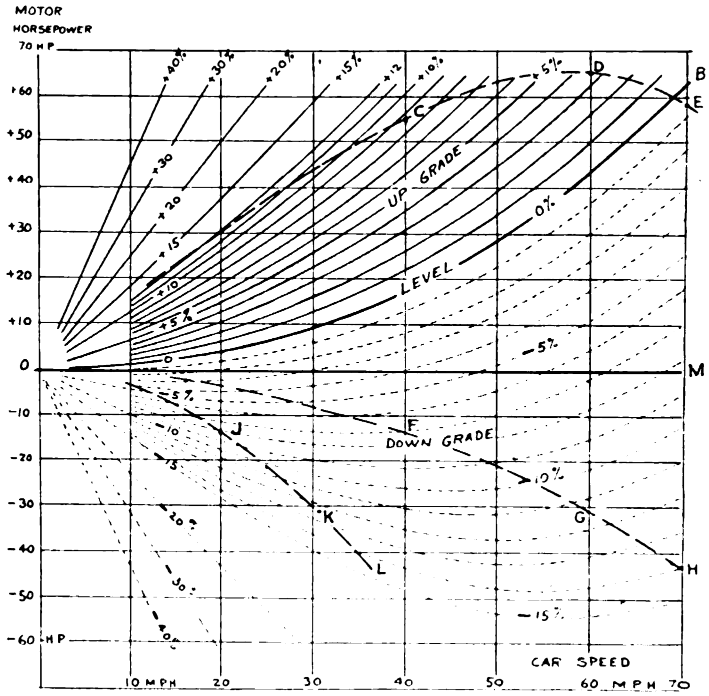


Fig. 2. TOTAL HORSEPOWER – ROLLING, PLUS AIR PLUS OR MINUS GRADE RESISTANCE
Full lines show h p required by 4200 pound car on up grade
Dotted lines show h p required by 4200 pound car on down grade
Broken line CDE shows engine h p, full open throttle, 2950 rpm at 60 m p h 3rd gear
Broken line FGH shows engine h p full closed throttle 3rd gear
Broken line JKL shows engine h p full closed throttle 2d gear

Maximum speed of 50 miles per hour on level requires engine horsepower of at least 30 h.p. Maximum speed of 60 m.p.h. requires at least 45 to 50 h.p. Maximum speed of 70 m.p.h. requires at least 65 h.p.

A typical engine horsepower curve has been drawn on Figure 2, indicated by reference letters C, D, E. The maximum power of this engine as shown by test was 65 h.p. at 2,950 r.p.m. In plotting the engine power curve on Figure 2, the maximum power was placed at a car speed of 60 miles per hour, indicated by point D, with other points of the power curve, as C, E, are proportionally placed in miles per hour. When the power curve CDE is studied with reference to its intersections with the grade curves, it can be seen that the car can climb a 12 per cent grade at speed 20 m.p.h., 8.5 per cent grade at speed 40 m.p.h. and level road at speed of 68 miles per hour. These characteristics put the vehicle in the high power, high speed class.

A smaller engine might have been used, say 50 maximum horsepower instead of 65, giving a satisfactory power plant for speed of sixty miles per hour. The power curve used in this illustration was from a La Salle car tested at the Mason Laboratory in 1927.

Engine as a Brake.

The engine horsepower curve referred to by CDE, Figure 2, may be called an open throttle power curve, as it shows only the maximum power that can be derived from the engine. An-

(*Continued on page 46*)

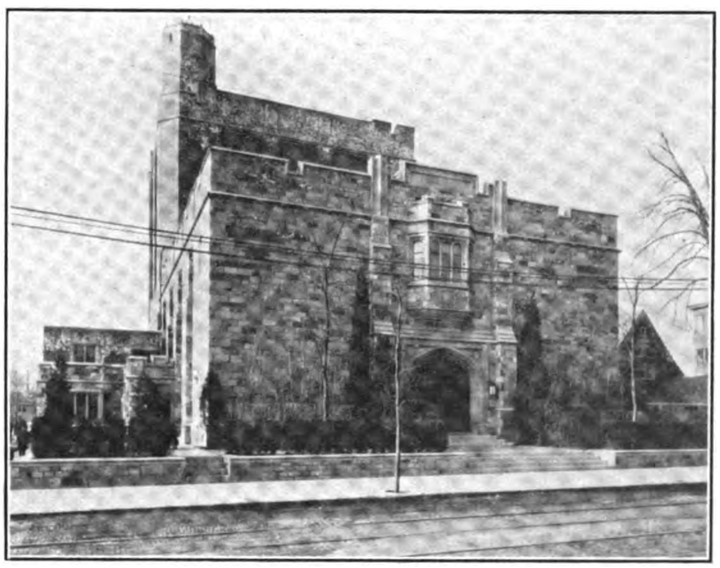
Science Helps Develop an Emotional Art

Stage Lighting Main Contributing Factor in Advancement of the Theatre by Improving Setting Provided for the Actors

By Sydney K. Wolf

THE art of acting deals with the interpretation of the emotions; science deals with reason. The fields thus represented are far apart, but the modern stage gives an example of the benefit which science has been to art. The actor of ten centuries ago interpreted emotions, according to the conventions prevailing, in a manner to influence his audience to as great a degree as could any modern actor under the same circumstances. The real advancement in the theatre, therefore, has not been made as much through the acquisition of skill in interpretation of emotion as in the improvement in the setting provided for the actors.

Stage lighting is the main contributing factor to this setting. Lighting bears the relation to acting that it does to the exhibition of a painting; the whole appearance of the painting is altered by lighting, and only under good lighting are the qualities of the picture shown to their best advantage. A brief resume of the development of stage lighting serves to illustrate the part played by science in the development of an emotional art.



The new Yale Theatre.

Dramas of the Greeks and Romans were held out-of-doors during the day time. There was no necessity for artificial illumination. Nevertheless some attempts were made to introduce a decorative element by coloring the daylight. Valerius Maximus, writing in 78 B. C., states that yellow, red, and blue awnings were stretched over the large theatres, and as the awnings fluttered they dyed the assemblage with a play of variegated colors from the transmitted sunlight. The Roman theatres apparently existed until about the fifth century. From then until the tenth century there is only little record of any dramatic performances. During the tenth century the miracle play was introduced. Crude open stages were erected near the churches, or in the public squares, but still the performances were held only in the day time. It was not until the thirteenth century that mention is made of the use of burning pineknots in wrought iron baskets for lighting the stage and the area around it.

Shortly before the time of Shakespeare the enclosed theatre came into use and performances were then given in the evening. Illumination was obtained from smoking and flickering lanterns, candles, and torches. From then on more thought was given to the arrangement and type of lighting. In 1628 a German manual describes the arrangement of candles or oil lamps in the position of the present-day floor lights and also in grooves behind the sides and top of the proscenium opening, where proscenium lights and border lights are now placed. Before the end of the eighteenth century several theatres had been built in America; these were all lighted with candles. The subsequent development of stage lighting virtually paralleled the development of artificial illuminants. In fact, so anxious were theatre managers and stage directors to improve the quality of their productions that new developments and improvements in illuminants were often used for stage purposes prior to their acceptance by the general public.

The oil lamp with the glass chimney superseded the candle and made possible much higher intensities of illumination. In 1803 illuminating gas was introduced; it was quickly adopted for use on the stage. The Lyceum theatre in London was the first to use illuminating gas, and the Chestnut Street Opera House in Philadelphia was the first in America. Many theatres soon followed these examples. There were no central gas plants in service at the time; the gas had to be manufactured on the premises. For the use of gas it was necessary to employ huge control tables, regulators, water joints, and pipe mains. Some of the pipe mains exceeded twelve inches in diameter, an indication of the magnitude of the accessories used for gas stage lighting.

About 1860 the lime light came into use, and since then this device has been intimately associated with the stage. The lime light consists of a piece of lime heated to incandescence by an oxyhydrogen flame; the brilliant and concentrated light which results, passed through a lens, gives a spot of light which is both uniform and brilliant. The electric arc, of which the light is somewhat similar in its characteristics to that of the lime light, was the first form of electric lighting used on the stage. The Paris Opera was the first theatre to use the electric arc. There the arcs were placed at the focus of parabolic mirrors and the reflected rays, sometimes modified by dyed silk screens, were used to simulate the sun.

With the adaptation of the arc light the so-called stage effects came into being. Light from the arc was directed through a glass prism to produce the effect of a rainbow, while flashes of lightning were produced by moving the carbons. The earliest arc lamps had to be adjusted by hand, and it was not until the introduction of the automatically fed arc lamp that they came into use for the illumination of the whole stage. In 1864 the first electric arc lights used for this purpose were installed on the

stage of the Paris Opera, where, mounted in rows, they replaced the gas footlights and border lights. A number of lamps were also mounted in metal reflectors, and served as "bunch lights" for flooding local areas.

Birth of "New Movement."

When the incandescent lamp became available, its advantage for stage lighting was at once recognized. Its introduction

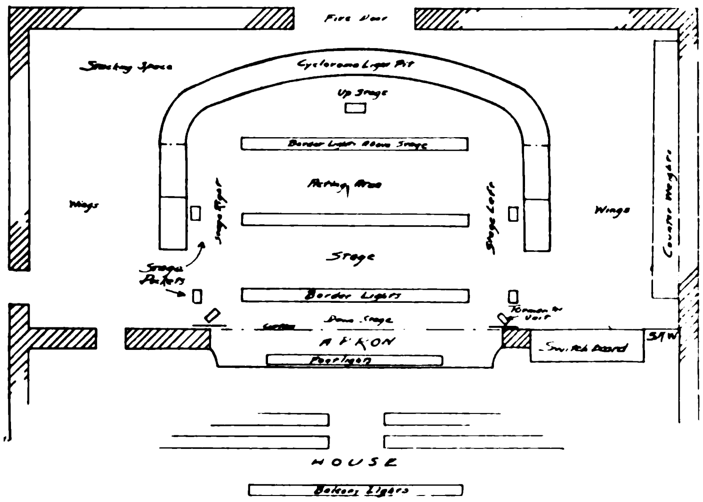


Fig. 2. Floor plan of a typical stage.

marked the birth of a "New Movement" in the art of stage lighting. Because of the ease of its control, its safety, and its adaptability to color modification it made possible modern stage lighting. At the present time incandescent lamps are used universally for stage lighting, only with the exception of high-powered arcs for long distance spotlights. And even these arc lights are being rapidly displaced by incandescent spot lamps of high wattage.

With the introduction of electric lighting a renaissance occurred in the theatre. The actor of ten centuries ago was potentially as good an artist as the actor of today. These potentialities were brought to their full realization during the fourteenth century. But the actor of that day had but little better setting for the exhibition of his artistry than his primitive brother. A rough gem on the one hand, a polished gem on the other, but both lost much of their beauty in a crude setting. There the matter rested. The setting which was to bring out the full beauty of the art of acting was not developed until the nineteenth century. Even then the potentialities of stage setting and stage lighting were not at once recognized; the tone of the theatre was one of conventionality and complacency.

The names which stand out as pioneers of the "new movement" are Adolphe Appia, a Swiss, and Gordon Craig, the son of England's great actress, Ellen Terry. Both these men concerned themselves with the stage as a scene for the setting of the play; both are responsible for the important place light has attained in the theatre of today.

At the time Craig and Appia began their experiments there was no lack of material on which to work. The authors broke with the old forms and created new, providing plays which were in themselves a source of inspirations for stage setting. Gorky, Tolstoy and Ibsen provided problems for the exponents of the new stage-craft, as did also Shaw and Galsworthy, Hauptmann and Sudermann, Von Haufmanstahl and Maeterlink. When the plays of these authors were to be produced it was apparent that they must be interpreted in a manner more sympathetic and individual than with earlier plays. The attempt to obtain atmosphere and effect, to appeal to the senses through the visual and decorative, marks the characteristics of the new movement.

Artist Seeks Luminous, Shadowless Ether.

The introduction of electric lighting brought many problems for its most effective use upon the stage. These problems were technical; experimentation was necessary to approach the ends sought. Often, too, the conception of these ends was nebulous in the minds of those who made the experiments; as is often the case, the artist asked the scientist to provide for a need which could not be defined concretely. This attitude is expressed in a statement of Edward Jones, who played an important part in the development of stage lighting. He says: "I choose light not only to bring out elements of character by slightly unfamiliar color and value just below the threshold of conscious appreciation, but also to make the players swim in a luminous, shadowless ether, the ideal of poetic atmosphere. They exist, so to speak, self-luminous and radiant, important, heroic,"—a rather difficult description for the scientist to work on, to say the least.

Many of the attempts at stage lighting have led to extreme and bizarre effects. Cults of stage lighting arose but mostly in Europe, for it was there that modern stage lighting was first experimented with extensively. In this country Belasco worked with lighting in an effort to make the scenes appear as natural as was possible. Joseph Urban of Vienna brought to America much of the development in lighting that had taken place in

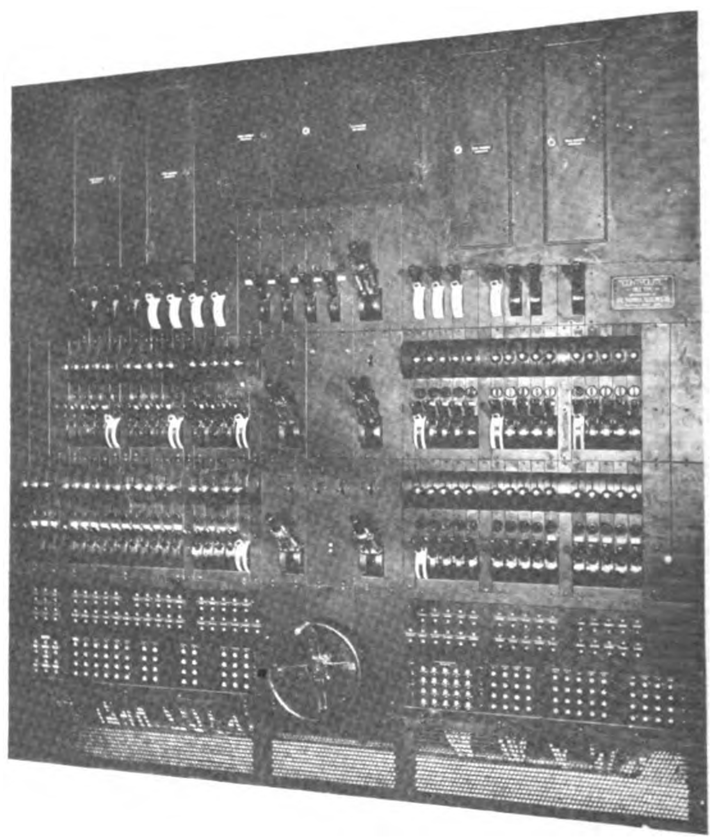


Fig. 1. Switchboard installed in Yale Theatre.

Europe. He was first with the Boston Opera House, but later joined Ziegfield and designed the light effects for the Follies.

No one system of lighting is suitable for all types of plays; the lighting must vary with the action and set it off to the best advantage but without intruding itself and detracting the attention of the audience from the actors. The diversity of effects necessary require elaborate methods for the control of lights and for the duplication of any given effect. This neces-

sity has led to the development of elaborate switchboards to control the various lights. The switchboard at the Yale Theater, illustrated here (Figure 1) is an example of the type used.

Varied Systems of Lights Needed.

Figure 2 shows a typical plan for the arrangement of lights in a theatre. The general illumination is obtained on the stage from permanent equipment such as footlights, borderlights, and proscenium lights. Localized illumination is obtained by the spot lights, bunch lights and flood lights.

The footlights direct a rather strong light from below, which intensifies the facial expression, and assist to some degree in holding the attention of the audience. Footlights tend to reverse the direction of the natural shadows; to counteract this effect lights of approximately the same intensity are placed above the stage. Footlights are not always used and some modern types are constructed so that they can be made to disappear beneath the stage floor when not in use.

The borderlights furnish general illumination from overhead. For the usual type of production they are a necessary part of the stage equipment. Borderlights originally were merely inverted footlights, suspended from the ceiling of the stage in such a manner that they could be raised and lowered, the number of sets necessary to satisfactory illuminate the playing area depending on the depth of the stage. Some theatres, for example the Metropolitan and Manhattan Opera Houses, employ seven or eight rows. David Belasco, who for some years has dispensed entirely with footlights, uses instead a borderlight from twelve individually controlled spotlights each focused upon a bowed circular disc coated with silver leaf. The conventional type of borderlights do not lend themselves to much flexibility or individual control.

Cyclorama Simulates Outdoor Scenes.

A cyclorama is used in outdoor scenes as a background to simulate the sky; set pieces such as trees and other natural objects are placed before it to complete the scene. The advantage of the cyclorama is that, when properly designed and lighted, it gives an illusion of great depth to the stage or distance to the scene. Cycloramas are made in various shapes, flat, curved, and domed. A permanently installed cyclorama is generally constructed of concrete and plaster. The surface is left rough so as to reflect light diffusely. Canvas possesses a good surface for cycloramas, but it must be tightly stretched in order to prevent folds which produce undesirable shadows.

The cyclorama is generally lighted by the use of several box sidelights or olivettes—the exact number depending on the area to be lighted. Lights are also laid at the bottom and focused vertically along the surface. Color changes are effected by another set of olivettes of the desired color similarly placed. Various tones of color are obtained by color mixing.

Proscenium lights are similar in design to footlights and borderlights. A row is mounted vertically behind each side of the proscenium opening. They reduce or eliminate any sharp shadows or contrasts that might exist in the vertical plane. In some theatres the proscenium lights are being replaced by vertical rows of baby spotlights, or a newer type of light called tormentors; each unit is operated individually, and can be used for spotting or flooding certain stage areas.

Floodlights or bunchlights are used for lighting an area to a greater intensity than the rest of the stage. Hand fed arc lights were formerly used for this purpose; later banks of ten or more incandescent lamps were bunched close together in one reflector, hence the name "bunchlights." With the introduction of the high wattage incandescent lamp the bunchlights have been replaced by 1,000-watt units, which have the advantage of greater efficiency, and can be controlled directly from the switchboard.

Lenses are used with lights when it is desired to call the audience's attention to an individual performer, a group, or a special part of the scene. For this spotlight with a single condenser lens in front of the light source is used to direct a strong concentrated beam of light with no stray or spill light. For extremely high intensity of light, electric arcs are used behind a condensing lens. These spotlights are equipped with spherical mirrors, properly focused behind the lamp to redirect as much of the emitted light as possible. In front of the lens of a spotlight are grooves for inserting gelatin screens for color modification, and some are equipped with color wheels containing a series of colored screens for rapid alterations of color.

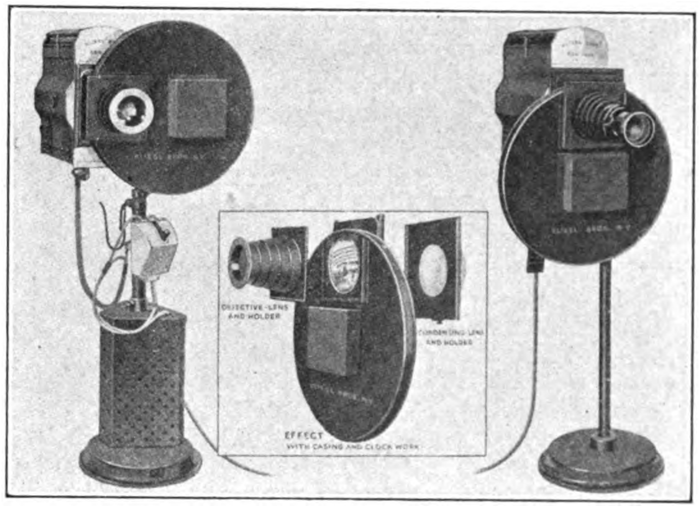


Fig. 3. Sciopticon used for producing dynamic scenic effects.

Dynamic Scenic Effects by Sciopticon.

There are times when a very sharply defined spot or design is desired, and to produce this effect an apparatus known as a sciopticon (Figure 3), similar to a regular stereopticon, is used. This apparatus has objective lenses in addition to the condenser lens, and also a carrier for lantern slides. By using an opaque slide with an opening of the shape desired, a spot of some particular contour can be obtained. Dynamic scenic effects, such as flowing water and moving clouds, and other fantastic effects are obtained with the sciopticon. A picture is painted on a mica disc or on vertical slides enclosed in a metal case, and these are rotated or moved vertically with clock works or a motor. The casing of the apparatus can be turned on a swivel so that, as in the flowing water effect, the movement will cross the screen. An infinite number of effects are produced by this apparatus; some of the standard effects are the Aurora Borealis, an avalanche, a cyclone with flying objects, flames, flowing water, a fog, a rainbow, a volcano, aeroplanes flying with moving clouds, etc.

The color of light depends upon the wave length. The fact that light waves of certain frequencies are visible and others are not depends entirely upon the physiological characteristics of the human eye. We cannot see radio waves because they are too long; we cannot see X-rays or Cosmic rays because they are too short. If sunlight is refracted by a prism or diffraction grating, every color will be produced, from violet the shortest visible wave length to red the longest visible wave length. Colors are produced on the stage by the mixing of colored lights in a manner similar to that of an artist in mixing colored paints. By

(*Continued on page 46*)

Unusual Facilities at Engineering Camp

Ideal Location, Well Planned Buildings and Fine Equipment Offer Excellent Opportunity for Practical Field Work at East Lyme

WITH the transfer from New Haven this year of all the courses in Plane Surveying, the summer Engineering Camp at East Lyme became the fulfillment of a long felt need of the Sheffield Scientific School. It was in 1913, through the efforts of Dr. R. H. Chittenden, then Director of the Sheffield Scientific School, and Professor John C. Tracy of the Department of Civil Engineering, that the Trustees of the Sheffield Scientific School secured the tract of land. By means of a committee headed by Mr. Smith Ferguson, '94 S., money and donations were pledged by members of the Yale Engineering Association and friends of the School to the extent that more than three-quarters of the building expense was raised through the Association alone—approximately eighty thousand dollars from over four hundred Yale alumni. The presentation of the camp took place on September 25, 1926, when members of the Engineering Association visited the camp, then in session, and formally gave the buildings to the Trustees of the Sheffield Scientific School.

The camp constitutes a realization of a plan to supply the best facilities not only for Plane Surveying, but for many other subjects such as Railroad Engineering, Highway Engineering and Water Supply Engineering, where the work can be done under suitable conditions and free from interruption. Although the camp was completed in August, 1926, it was first put to its full use this year. From now on it will be the first scene of "Sheff" life to the incoming Sophomore classes in Engineering.

The camp was in charge of Professor Charles S. Farnham, who was also resident Engineer in charge of construction during its building.

Location of Singular Beauty.

The tract, which was selected after visiting locations in all parts of Connecticut and portions of other states, reaches for three miles and a half up a valley whose extreme width is three miles, in the vicinity of East Lyme. The land is partly cleared; the rest being wooded or wild and rugged. Its remoteness from any village or town gives the desired freedom and privacy from outside influences. The location, on the shores of a lake, is of singular beauty that is appreciated in full only by those who have been there.

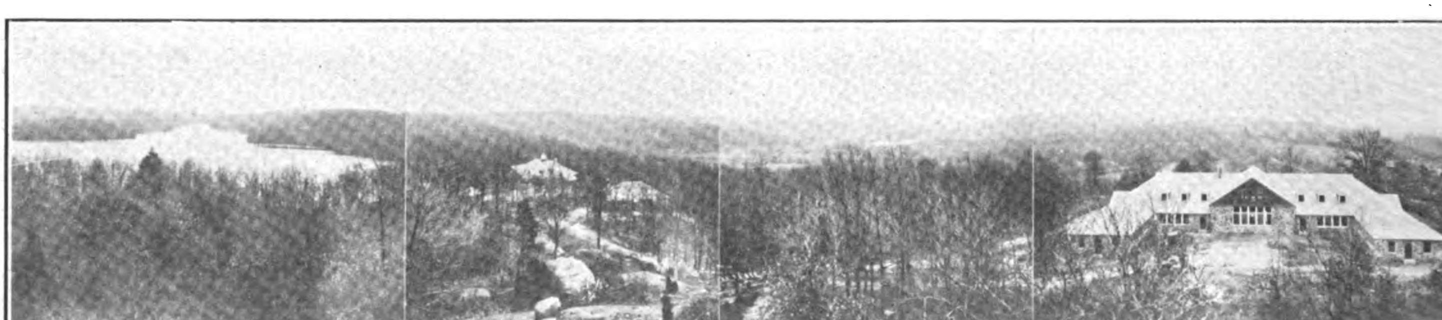
The buildings are ten in number. The Instruction Hall contains on the ground floor a large room for assembly, four recitation rooms, four drafting rooms and four offices for instructors. The plan is in the form of a letter "H" with the drafting rooms so placed in the wings as to have light on three sides. About four hundred feet from the Instruction Hall is the kitchen, surrounded on three sides by an open air Dining Pavilion. Between the kitchen and Dining Pavilion are a serving pantry and a dishwashing room. In the rear are a baking room and a store room for provisions. Every modern convenience for the preparing and serving of food is provided. The Instruction Hall has overall dimensions of 157 x 138 feet, while the Dining Hall measures 73 feet by an extreme width of 87 feet. Midway between the main Instruction Hall and the Dining Hall is the Instrument Building, where a large collection of surveying instruments is kept during periods when the camp is in session; a large fire-proof vault being provided to store them during the rest of the year. These three buildings are built of field stone taken from stone walls nearby and are practically fireproof on the outside. The interior finish is of the simplest character. The buildings stand on a hill, from which there is a view of the surrounding country. In the rear of the hill a few hundred feet away is a lake one mile long, which lies wholly in the tract of land. Along the shore of the lake are located seven frame buildings of a single design, each of which serves as barracks for fifteen students.

A water system has been installed with an artesian well and a large spring as the sources of supply. The water from the spring is pumped to a stone and concrete reservoir, situated on top of the hill. Electric light and power are obtained through a line constructed from a point about two miles from the camp. About two thousand feet of road have been constructed leading from the main highway to the camp buildings.

The general plan for the buildings, roads, water supply, and other features of the camp were prepared by the Department of Civil Engineering. The architect for the buildings was Mr. Douglas Orr of Orr and Del Grella of New Haven. The buildings were constructed by the T. J. Pardy Construction Company of Bridgeport.

Organization of the Camp.

The opening of the camp last spring came with the assembling of the Sophomore Class in Plane Surveying on Saturday, June 11th, though regular class work did not begin until the follow-



Panoramic view of the Yale Engineering Camp at East Lyme, Conn. In the right foreground is the Instruction Hall while the Instrument Building and the Dining Hall can be seen in the center with Sheffield Lake on the left.

ing Monday morning. The intervening time was taken up in unpacking and settling the camp. The work of issuing blankets, keys, lanterns and other items of barracks equipment was quickly accomplished by several of the instructors detailed for the purpose, so that in a hour or two the entire group of over one hundred men were installed in the barracks along the lake shore.

Assemblies of the camp were held in the Great Hall on both Saturday and Sunday evenings for the purpose of welcoming the new men and to issue programs and give some suggestions concerning a few regulations shown necessary by experience in former camps. Professor Suttie, Sophomore Class Officer, took the occasion to give a few words of advice and encouragement

Instruction Hall which contains four recitation rooms, four drafting rooms, the Great Hall and offices

to the men whose first contact with the Scientific School occurs through the medium of the Plane Surveying Course at the summer camp.

For administrative purposes it was necessary to divide the class into four groups, each in charge of a corps of instructors and occupying one of the four large drafting rooms with accompanying lecture hall. To promote class unity and to facilitate making announcements, frequent assemblies of the entire class were held in the great hall of the main building. Here brief addresses were made by members of the instructional staff or by representatives of the student committee.

Radio Proved Source of Entertainment.

Through the generosity of Dr. Loomis Havemeyer an exceptionally fine radio set was installed on the west balcony of the Great Hall. This proved a source of constant entertainment and interest, as on several occasions it afforded a means of contact with the outer world by announcing events, such as Lindbergh's flight to Paris, results of boat races and other college events, and, in particular, the big fight at Chicago, which occurred during the September session.

This year the registration for the course in Plane Surveying was considerably in excess of the capacity of the barracks, which are arranged to accommodate a maximum of 105 students. It was necessary, therefore, to require a portion of the men to attend a similar course to be given in the fall. This plan of giving the surveying courses once in July and again in September is of considerable advantage to students who are members of athletic teams and to those who desire to spend the early summer months abroad or perhaps as counselors in boys' camps. The June course ended on July 6th and the September course on September 28th.

Excellent Sanitary Conditions.

In accordance with the regulations of the State Board of Health an inspector from that Department visited the camp and spent an entire afternoon investigating every part of the camp equipment, especially that connected with water and milk supply, ventilation, waste disposal, refrigeration, barracks, toilets and wash house. As the camp drinking water is drawn from a drilled well over one hundred feet in depth and is shown by bacterial examinations to be nearly sterile, and as all milk used is pasteurized in dairies inspected by the Board, the camp received a rating of "Excellent." To assist in maintaining the high rating awarded by the Board of Health, a copy of the report was conspicuously posted in the Great Hall and members of the camp committee urged to report any violations of the sanitary code coming to their notice. No violations were reported either by students or faculty. The camp was notably free from illness.

An electric siren mounted on the tower near the main building was found very effective in giving signals for meals and for the various class assemblies. Current for operation was taken directly from the regular light circuit, with operating buttons at several points in the drafting rooms, also at the Dining Hall and general headquarters in the Instrument building. Under favorable conditions the shrill note of the siren could be distinctly heard by surveying parties several miles from the camp.

At the barracks rough stone fireplaces and log benches were gradually developed in front of each building. These served as general gathering places, especially in the evening just before bed time.

The lake represented the greatest single recreational feature of the camp during the day and it was continually in use for boating, swimming and diving. Bridge was easily the most popular evening game, the favorite location for which was in front of the big fireplace, while the balconies of the main hall were also frequently occupied.

Mention should be made of certain pieces of physical equipment which were added to the camp this year. Original plans provided for an ice house to be filled from the lake so as to supply natural ice to the large refrigerators in the dining hall. Later studies indicated the economy and desirability of installing mechanical refrigeration. The large rustic gate of red cedar at

Dining Hall which overlooks Sheffield Lake has modern facilities for the preparation and serving of food.

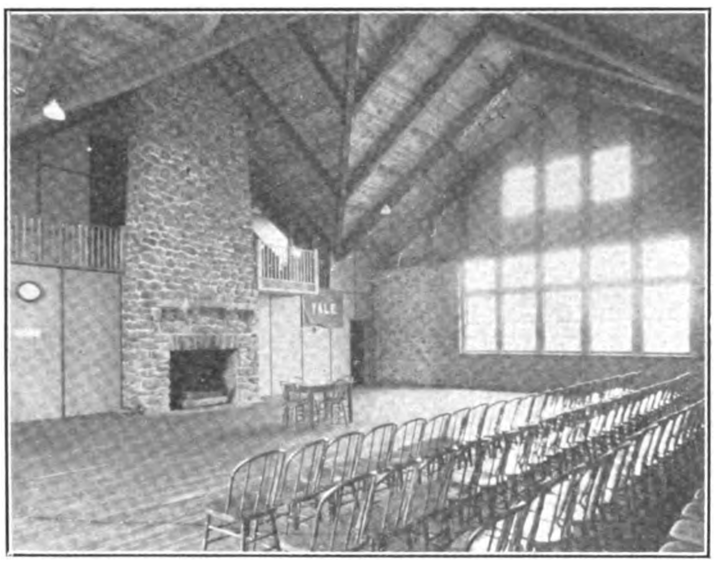
the entrance to the camp road was put up during the summer and, when it is later flanked with a substantial paling of the same material and grading completed, a dignified approach to the camp will result.

Field Surveys Made More Interesting.

The content of the courses in Plane Surveying remained substantially as in former years with the exception of the field surveys of the final week of each course. These were made more interesting and instructive by assigning particular areas on several farm tracts to each field party which was required to make a complete survey of the tract by transit and stadia checking and preserving the field notes for mapping which occupied the

closing exercises of each course. The men enjoyed the practical application of the subject and many of them did a considerable amount of evening work in order to have the maps complete in detail and attractively lettered. The ratings awarded by the Instructors indicate that the students' efforts in this particular were well directed.

A further variation was adopted in the September course by making a complete survey with map and profile of the town road from camp to the village of East Lyme. Owing to the distance some of the parties had to go for this work, it was necessary to make considerable use of the camp truck. Several students also offered the use of their own cars for transporting men and instruments. This survey and map had previously been requested by the Selectmen and Road Commissioners of the town, to whom selected copies of the maps will later be donated with a view to improving the entire road by widening narrow places, removing projecting boulders and improving the surface and alignment wherever necessary. The Selectmen have already been informed of the co-operation on the part of the men at the camp and have expressed their appreciation for the work accomplished.



Interior of the Great Hall used for general meetings and recreational purposes

Forestry School Uses Camp.

An additional use of the camp was begun when on Monday, July 11th, the students of the Junior class of the Yale School of Forestry arrived at camp for the regular summer course of ten weeks. For the past twenty years it has been the custom to conduct this work at Milford, Pennsylvania, at a camp especially built for the purpose on land of Mr. Gifford Pinchot, former Forester of the United States. Extensive lumbering in that locality, together with the destruction of all chestnut trees by blight have so reduced timbered areas near the school that it was decided by the Faculty of the Forest School to conduct the course at East Lyme Camp this year. Although the class was small, numbering only eight students, they presented the usual diversity of countries and states from which classes in the School of Forestry are so largely recruited. Australia, South Africa, Russia, the Philippines and Canada sent one representative each, while men from the South made up the balance of the class. Accustomed to camping and to life in the open, these woodsmen quickly established themselves in their new surroundings and at once took up the work of the required courses in Dendrology, Forest Mensuration and Plane and Topographic Surveying. As the camp forests have been allowed to grow unmolested for about fifteen years since their purchase by the Sheffield Trustees, they now contain some excellent stands of oak, hickory and other mixed hard woods which proved satisfactory for instructional purposes. Practical work was illustrated by means of selective thinnings and growth studies which were undertaken on various portions of the forest. In connection with this work a number of mature trees were cut for the purpose of analyzing heights and volumes. The varieties of trees and woody plants occurring on different parts of the camp property afforded satisfactory material for carrying on work in Forest Botany. Professor G. F. Rupp, M.F. '26, of Pennsylvania State College, took charge of the instruction in Forestry, assisted by R. I. Ashman, '27 F. Work in Surveying was in charge of Mr. R. B. Allen, '23 S., of the Department of Civil Engineering.

Both students and instructors concur in the opinion that the camp offers exceptional facilities for the conduct of summer courses of this character.

Juniors Make Topographic Survey.

Juniors in Civil Engineering and Mining Engineering are required to spend the month of September at the camp devoting their time to a topographic survey of a portion of the camp property. Interest is added to this work by the opportunity offered each class to survey a section of the property not previously surveyed and mapped. This year the class surveyed the area immediately north of the camp and extended the system of horizontal control points for at least a half-mile further so as to facilitate the field work of succeeding classes. Important survey points are marked by substantial hubs of red cedar or black locust, both of which possess high resistance to decay, although constantly in contact with moist earth. All calculations and field sheets are carefully checked and preserved for use by future classes. To facilitate the matching of field sheets made by different classes a system of co-ordinates referred to a true meridian is employed, and the true azimuth of some important line is checked by each class by means of astronomical observations. As no Government bench marks were established near the camp it has been necessary for several years to refer all surveys to an assumed level datum. During the past year, however, the United States Geological Survey has determined the elevations of several permanent marks along the Boston-New York Post Road south of the camp. To refer the camp bench marks to sea level datum the Juniors ran a line of precise levels about a mile in length connecting the camp system with that established by the Government. This work will enable all future maps to show the elevations of various portions of the camp property with reference to sea level.

Seniors Locate Railroad Line.

The Senior Civil Engineers devoted their time wholly to the location of a railroad along the valley of Four Mile River, which flows for over three miles through the camp property. The class this year had the distinction of completing the location to the extreme northerly limit of the tract. For a number of years the practice has been followed of requiring each Senior class to make a careful study of a new portion of the valley with a view to extending the line already projected by former classes. By this plan the work of each class supplements what has already been accomplished and has in some cases made extensive relocation and regrading necessary. This feature of the work is of particular value since it effectively illustrates the need for com-

(*Continued on page 53*)

Next Great Revolution Will Be Biological

Hopeful Counter Tendency to Unwise Practice of Birth Control Revealed in Larger Families of Superior Stock on All Social Levels

By Ellsworth Huntington

THE discovery of America, the invention of the steam engine, and the growth of modern invention have revolutionized civilization. Life in New York today amid skyscrapers, automobiles, telephones, movies, apartment houses, subways, department stores, ocean liners, radio outfits, murders, gangs, uplift organizations, bridge clubs, stock exchanges, and a bewildering variety of other mechanical appliances and social organizations is almost incredibly different from life in the same place two hundred years ago. In the outward aspects of his life, the New Yorker of 1927 differs from the New Yorker of 1727 far more than the man of 1727 differed from the civilized Egyptian five thousand years ago.

Can so great a revolution ever again occur? I believe that it can. Indeed a far greater revolution already seems to be well under way. Its first effects are very bad, but back of them one can detect tendencies of another kind which are wonderfully hopeful. The last revolution was mechanical; the next will be biological. The last changed man's environment; the next will change human nature. Already the biological character of modern nations has begun to change with astonishing rapidity.

ALTHOUGH the biological character of our people has been undergoing an alarming change during the last two or three generations, there is a hopeful side to the matter in the growing tendency toward larger families among the more successful, more self-controlled, and more valuable people which leads toward steadily rising standards in every class.

Here is an example. The families of the British nobility which have held an hereditary title for at least three generations may be better or worse than those of the unskilled laborers, but be that as it may, they are nevertheless different. These aristocrats differ from the laborers in physique, in intellect, and in temperament. A century or more ago the two groups differed only a little in the size of their families and in the rate at which they increased through excess of birth over deaths. Today they are as far apart in this respect as in others.

Nobility Dwindling While Laborers Increase.

The difference has come to pass in this wise, according to Professor Whetham. Among the members of the old British nobility who were married from 1831 to 1840 and who had children, the average number of children per family was 7.1. This is nearly the same as the number among the laboring people at that time. If we allow for the much higher death rate among the children of the laborers than among those of the aristocrats, it appears that at that time England's upper classes were probably increasing at least as fast as the lower classes, and probably faster, although the exact facts are not available. But a two-fold change was under way, for birth control came into fashion, and medical science began to reduce the death rate.

The result was that among the nobility the birth rate dropped to 6.1 children per fertile family for the two decades from 1841 to 1860; it fell to 4.4 among couples married between 1871 and 1880; and to only 3.1 among those married from 1881 to 1890 —the last group whose families were complete when this study was made. Thus half a century saw a decline of nearly 60 per cent in the birth rate of the nobility. The decline in the rate of survival was not quite so great, for the number of deaths as well as of births diminished because of improvements in medical practice. Nevertheless the aristocratic families received less benefit from this than did other people, for their children have always been comparatively well taken care of. The net result is that today among the old British aristocracy, in the families where there are any children at all, an average of approximately 2.5 children per family grow to maturity. If we assume that 90 per cent of these marry, and that 85 per cent of those who marry have children, as seems to be approximately true, a hundred people in the present generation will be represented by only 95 in the next. Let that sort of thing go on for a couple of centuries and a thousand members of the present aristocracy will dwindle to only about seven hundred.

Meanwhile what is happening to the laborers? Although their birth rate has fallen a little, it still remains about twice as high as that of the so-called upper and middle classes. The percentage of laborers who marry and have children is higher than in the other classes. Moreover, the decline in the death rate of their children has been far greater than among more intelligent people, simply because where things are very bad it is easy to improve them. The result is that a hundred persons in one generation increase to at least a hundred and fifty in the next. At that rate—provided present tendencies continue unchanged—a thousand people in the laboring classes of today will increase to approximately 11,000 in two centuries. Even in the two or three generations in which the present tendencies have been in operation, there has been time for the less competent classes to become two or three times as numerous as they were before, while the more competent or more successful types have actually decreased.

There is nothing exceptional about this. A study of the children listed in *Who's Who in America for 1926-7*, which Mr. Leon F. Whitney and myself have published in *The Builders of America*, shows that in practically every group of leading people, whether in professions or business, there has been a decline in the birth rate like that among the British nobility. The older lawyers, engineers, ministers, politicians and others have more children than the younger ones, even when we confine ourselves to persons whose families are complete. This decline is typical of the whole group of people who form what we call the upper

classes, that is, the professional people and those engaged in the larger forms of business.

On the other hand, in America, as in England, the birth rate among miners, farmers, and ordinary unskilled laborers has declined only a trifle. Here, as there, the children of the average laborer are about twice as numerous as those of the average professional man or successful business executive. Moreover, even among the portions of the upper classes where marriage is as common as formerly, the proportion of childless marriages has generally increased. This is apparently not so true of the laboring classes, a condition which still further emphasizes the growing difference between the rates at which the different kinds of people reproduce themselves. In fact the difference has reached such a point that the present upper classes *as a whole* are rapidly declining in numbers, while the lower classes are rapidly increasing.

Lower Classes Do Not Produce Leaders.

Is there anything to worry about in all this? Are not plenty of people in the lower classes more valuable than such "effete and artificial" groups as the British nobility or even the professional classes of America? Undoubtedly many competent children are born in the lower classes, but the percentage who become leaders is far lower than in the upper classes, as appears from a dozen different investigations. Although the list of names in *Who's Who in America* might profitably be revised, it comprises an excellent sample of the more competent people of America. Yet in the edition of that book for 1922-3, according to Professor S. S. Visher, there is only one son or daughter of an unskilled laborer for every 48,000 families of such laborers in the population as it was when the persons in *Who's Who* were born. The farmers do better, but only one family out of nearly 700 produces a leader mentioned in *Who's Who.* Contrast this with the engineers who furnished one leader for every 160 families; the physicians and Methodist ministers, with one for every hundred families; the professional men other than clergymen with one in fifty; the clergymen of all denominations, one in twenty; and the Unitarian clergymen, one in seven. A list of leading scientific or literary men, or of leaders in almost any other occupation, shows a similar condition. In the face of all this, it is idle to repeat the common assertion that Lincoln's humble origin proves that the lower classes can be relied on to produce plenty of leaders. They never have done so, and there is not the slightest indication that they ever will.

Even when people from the lower social levels do rise to leadership, they do not biologically re-enforce the upper class to any great extent. Our study of *Who's Who in America* shows that when people rise from the lower to the upper classes, they not only have fewer children than does the class from which they came, but the size of their families actually drops below that of their colleagues of equal ability who come from the upper classes. In other words, under our present social system, the mere fact that people rise from the lower to the upper classes automatically reduces their families to such a degree that as a group they do not reproduce themselves—an astonishing fact, quite contrary to common belief. Thus from the biological point of view we are making a bad matter worse by searching for the able young people in the lower classes and lifting them to the upper levels. This doubtless increases the individual contribution of such people to social progress, but it harms the lower classes biologically as well as socially by removing from them their most able people, the ones who would also be the parents of the finest children, and it does not bring a corresponding biological advantage to the upper classes.

Extremely Drastic Process of Selection.

The net result of all this is that during the last two or three generations an extremely drastic process of natural or social selection has set in. It has arisen because the more thoughtful people in civilized lands have seen the necessity of birth control and have accordingly limited their families, whereas the less thoughtful have not yet realized this need. Its intensity has been greatly increased because during the same period the death rate, especially that of the children, has been greatly reduced among the less competent groups and only a little among the most competent. Thus, to use technical terms, the biological character of our people is today being rapidly changed by a decreasingly intense differential death rate and an increasingly intense differential birth rate, both working in the wrong direction.

We human beings are undergoing essentially the same process as that by which we produce strains of corn for example, with eighteen rows instead of eight, or of dogs with a keen ability as pointers. But somehow or other, when the argument turns to man, a vast number of people shut their eyes to it. Mankind, they say, has gotten along pretty well in the past, and will get along in the future. But that is no argument. Who can tell how much happier the world might be today if our ancestors for a thousand years had used sound scientific judgment as to marriage, birth control and the like? Moreover, in the only periods that we know of when conditions resembling those of today have prevailed in these respects, as in the days of the decline of Rome, civilization has gone down hill very rapidly. But even in Rome it is doubtful whether the changes in birth rates were so startlingly great and rapid as among us.

Successful College Men Have Largest Families.

The pessimistic point of view thus far presented must not blind us to the hopeful side of the matter. This is emphasized by the results of a recent investigation of Yale and Harvard graduates. Choosing from each college three classes that graduated so long ago that their positions in life are assured and their families in most cases complete, Dr. J. C. Phillips and myself obtained a rating for each man according to his success in life. The ratings were made by groups of men from each class. The successful man was defined as the one who is of the most value in making the community a better place in which to live.

The results were astonishing, and were identical for both colleges. Dividing the 700 Yale graduates, for example, into ten groups according to their success in life, we find an almost perfectly regular gradation from the most successful to the least successful in several highly important respects. First, the most successful men are married in much larger proportions than the least successful, the percentages ranging from about 95 among the most successful to about 67 among the least successful. Second, the most successful tend to be married younger than the least successful; the difference, however, is not great, the age being slightly under 30 for the most successful tenth and about 32 for the least successful. Much more important is a third fact, namely, that among the most successful tenth, no less than 80 per cent have children, whereas among the least successful this falls to about 40 per cent. The net result is that the most successful on an average have about three times as many children per graduate as the least successful. The most successful are maintaining themselves and are increasing a little from generation to generation. Unfortunately, the rate of increase is very slight, but it is enough so that if it should continue, a thousand men of the present generation would have approximately 1,150 great-grandsons. On the other hand, the least successful tenth

is diminishing very rapidly, and a thousand of the present generation bid fair to have not much more than fifty great-grandsons.

Counter Tendencies Affecting Society.

A similar tendency toward larger families among the more successful, more self-controlled, and more valuable people appears to exist in other levels of society. It has not yet been carefully investigated, however, and probably becomes weaker as we go down in the social scale. Nevertheless, its existence is unmistakable, especially in the upper classes. It indicates that two diametrically opposed forces are at work. One arises partly from the caution, thrift and foresight, which cause intelligent people to limit their families in order to avoid the difficulties of over-population and poverty. It also arises from the unwholesome mode of life which all too often prevails among people who acquire a competence. Its effect is to cause the birth rate to decline from the lower to the upper levels of society.

The other tendency arises from the fact that splendid qualities like love of children, love of home, self-control, and the willingness to sacrifice one's self for the sake of one's children, tend to cause people to have relatively large families. When these qualities are coupled with thrift, common sense, intelligence, and high ideals, we get the highest type of people. Although people of this kind are strongly influenced by the other tendency, which leads toward small families, they are also influenced in the other direction, so that their families are a good deal larger than those of the less valuable elements within their own social groups.

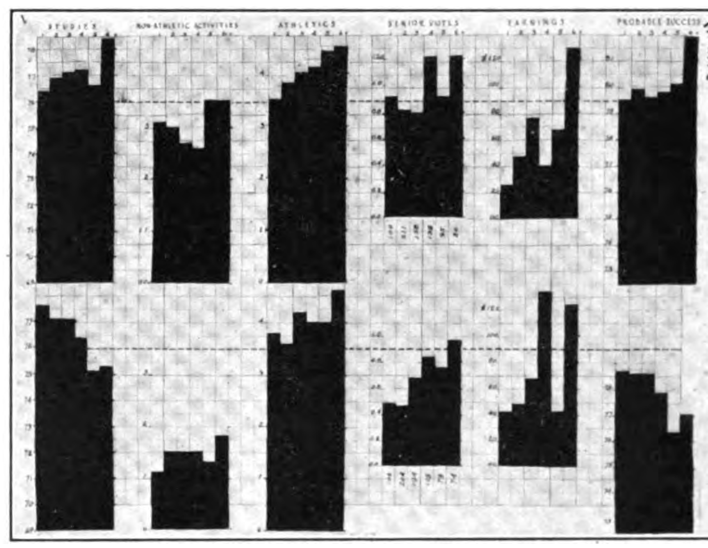
The first of these tendencies seems to lead inevitably toward the rapid decline of civilization. Even though it acts slowly among us, its ultimate results may be not unlike those which have occurred in Russia. There one of the chief effects of the Revolution was to cut off practically the whole upper class and many of the strongest elements in the lower classes. The few leaders who remained were an almost negligible proportion of the population as a whole, and many of them were of highly selfish or one-sided types. A slow disintegration leading to conditions somewhat resembling those of Russia is what we may expect if this tendency prevails unchecked.

The other tendency acts in exactly the opposite way. It leads toward steadily rising standards in practically every line. If all this is true, the logical conclusion seems to be that we ought to devote ourselves most strenuously to a two-fold program of biological improvement. One side of the program would be aimed at the reduction of the birth rate among the less competent and less valuable parts of the population, no matter in what social level they may occur. The other side should be aimed at the encouragement of large families among competent people of every type.

The most valuable people of all are, of course, those who combine the highest type of intellect with common sense and with the temperament that makes them not only practical but self-controlled, persistent, able to work with others, lovable, and able to lead. The aim should be many children in families of this type, and fewer and fewer as we depart farther from it. All along the line the kind of temperament which makes good citizens is even more important than intellect. For that reason many people in what are called the lower, as well as the upper levels of society, ought to be encouraged to have large families. Yet in general the upper classes contain the most valuable types, for there alone do we find many people who combine high intelligence with fine qualities of temperament.

Children from Large Families Most Successful.

At this point someone may say, "How about the children? Are not they much better off in small families than in large?" A study of 1,700 men who graduated from Yale College in the classes of 1922 to 1926 answers this question. The standing of these men in activities of all kinds during their college careers was compared with the number of their brothers and sisters. In order to obtain a homogeneous group from nearly the same social level, those whose fathers were college graduates were treated separately. Here are the astonishing results: The class room work for the entire four years of college shows a well-nigh perfect gradation from relatively low marks on an average among those who were the only children of their parents up to a fairly high average among those coming from families of six or more. In non-athletic activities outside the class room, the case is similar although not quite so clear. The students from families with five, six, or more children decidedly excel those from



Success in college among sons of college graduates (above) compared with sons of parents who did not go to college (below), In each of the twelve diagrams here given, the left hand section (labelled "1" at the top) indicates graduates of the Yale College Classes of 1922 to 1926 who are the only sons of their parents; the next section (labelled "2" at the top) indicates those who have one brother or sister, but no more; the third section ("3") indicates those who came from families of three children, etc. The number of graduates in each group is indicated under the two diagrams for Senior Votes; these figures apply to all the diagrams except those for earnings, which are based on less than half as many.

the smaller families in literary, dramatic, religious, and musical activities, in managing athletic teams, in student government, and the like. In athletics there is a most extraordinary regularity in the way in which those from the larger families take a greater part and are more likely to be leaders than are those from the smaller families. In senior votes as to which man is the hardest worker, the most representative Yalensian, the most likely to succeed, and the like, a similar condition prevails. The regularity with which the votes rise from the men who are only children up to those who come from families of six or more, is not so great, to be sure, as in athletics or studies, but the students from the families with four or more children decidedly overshadow those from the smaller families. Finally, in earnings, according to the records of the Bureau of Appointments, the fellows from the larger families systematically stand higher than those from smaller families. Of course this last is just what would be expected, for the fathers of the big families find

it difficult to educate so many children. But bear in mind that the fellows who earn the most—the ones from families of six or more children—are also the most popular and the most respected among their classmates, as indicated by senior votes; they take the greatest share in athletics; they hold the most prominent positions in non-athletic activities outside the regular curriculum; and they decidedly overtop all the others in their studies. Of course there are many exceptions to all this, but taking the averages of large groups, the case seems perfectly clear. It is a decided advantage to belong to a large family.

Training and Inheritance Both Active Factors.

Is this advantage due to inheritance or training? This question is partly answered by the Yale graduates whose fathers were not college graduates. Among such boys there is, of course, a wide social difference. Some come from families which stand near the top of the social pyramid, others from families far down toward the bottom. This explains an interesting and pronounced anomaly. In their studies, the Yale graduates who are the only children of parents who did not go to college stand decidedly higher than the others, and there is an almost regular decline in scholarship as we pass to larger families. This agrees with what we should expect.

The small families among the parents who did not go to college are likely to belong to alert intelligent people who are rising in the social scale, and for that reason limit their families. A study of *Who's Who* shows that the men in that book who do not have a college education limit their families more than do the others. Intelligent people of this type, no matter whether in *Who's Who* or outside of it, are likely to have intelligent children. On the other hand, among the parents who do not go to college the larger families are likely to be found among people of the so-called lower middle classes—carpenters, farmers and the like. Their children are less likely to inherit high intelligence than are the children of those who have risen to the so-called higher levels and therefore have limited their families.

In all their college activities aside from the class room, the students whose parents are not college graduates behave like the sons of college graduates so far as the size of families is concerned. In other words, boys from the bigger families are systematically more prominent as leaders in extra-curricular activities aside from athletics; they make higher athletic records; they receive a much higher vote from their classmates in senior year; and they earn much more. This seems to indicate that the training in the family has a great deal to do with a boy's success. His intellectual inheritance may determine his position in the class room, but elsewhere the training he gets at home appears to be at least equally important. If he is an only child he lacks the rough and tumble contacts with brothers and sisters which rub off the corners, make people considerate of others, and teach them how to get along in the world. The popular notion that children are benefited when families are limited to two, let us say, is completely wrong so far as Yale College graduates are concerned. The bigger the family, the more likely a boy is to succeed in college. Moreover, our studies show that success later in life is almost equally correlated with success in studies on the one hand, and in extra curricular activities aside from athletics on the other hand. Athletic success, be it noted, shows no appreciable relation to success in life. The thing that counts most in life, apparently, is the intellectual inheritance which usually belongs to the boy who comes from a genuinely high-grade family, and the training which a boy gets among a considerable group of brothers and sisters.

If all this is true, it greatly re-enforces our previous conclusion that large families are especially desirable among the people of the finest types. But how is it ever going to be possible to get such families? The answer is that already there is a strong tendency in that direction. We have seen it in the relatively large families of the most successful graduates of Yale and Harvard. It is also evident in certain places where birth control has been practiced so long that it is common among all classes, and has ceased to be regarded as a fad, or a new discovery among the people of greater intelligence.

Stockholm Striking Example of Saving Tendency.

The city of Stockholm is the only place of this kind where exact data are available. In that city Mr. Karl A. Edin finds that in the years 1919-1922, the average number of children per family was about twenty-five per cent lower among industrial workers than among the upper, or professional and executive classes.* The numerical advantage of the upper classes is still further increased by the fact that the death rate among their young children is about twenty per cent lower than that of the working classes. Thus where there are a hundred children in a given number of families among the upper classes, there are only about sixty-five among the workers in industry.

Still more significant is the fact that couples having an income of at least 10,000 Swedish crowns (about $2,700) in 1920 had a birth rate fifty per cent above that of couples who had an income of less than 4,000 crowns ($1,080), but yet were above the level of laborers. The birth rate is still lower among the laborers who of late years have been strongly influenced by communist propaganda in favor of birth control. Thus in Stockholm the number of children per family is very closely adjusted to the income. Those who can afford children have them, and those who can not afford them have few. So, too, in the families that can afford to support children relatively few die, while in those who cannot afford to support them the number of deaths is great. Of course, the adjustment between income and the number of children is by no means perfect. Professional women, for example, although they belong to the upper classes and have at least moderately good incomes, have a birth rate only a third as great as that of the city as a whole. On the other hand, a middle group of laborers—neither the highest nor the lowest—have a larger birth rate than do the groups above and below them. Nevertheless, the general fact remains that in Stockholm, quite unlike the United States, England and most of the civilized parts of the world, the birth rate in general increases from the lower to the upper levels of society. It acts precisely as does the birth rate among the graduates of our colleges, and it conforms to what appears to be the ideal.

Results in High Social Level.

Do the conditions of Stockholm suggest that this is a good thing or a bad? Everyone who knows Stockholm seems to agree that as an example of high civilization that city stands close to the top. Although it is a large place with over 400,000 inhabitants, it is clean and wholesome in a way that is practically unknown in cities of equal size in any other parts of the world. There are no such things as slums. Of course, there are tenements—many of them—but not so many as in most cities of corresponding size. If any of these tenements shows a tendency to develop in the direction of slums, the public authorities promptly intervene. The people who might produce slums are

* Dr. Edin's English summary of his work does not state whether he included illegitimate children, which are very numerous in Sweden, partly because of the prevalence of trial marriages. How far the inclusion of such children would alter the results here given is not clear.

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Fireproofing of Wood a Growing Industry

Cheaper Method of Handling and More Effective Treating Substances May Reduce Cost so as to Extend Limited Market

By Prof. G. A. Garratt

WITHIN comparatively recent years the complexion of the building industry in the United States has undergone a marked change, particularly in urban districts, and a wide replacement of wood by other structural materials has been in evidence. Enormous increases in real estate values and attendant demands for more intensive use of space in the dense centers of population have stimulated detailed studies of forms and materials and led to outstanding developments in architecture and engineering. Wooden buildings have been replaced by structures in which wood can be used only in part. The detached frame dwelling has given way to the apartment house, and the steel skyscraper of fireproof construction has taken the place of the old business block in which wood was an important construction material. Even in the less congested suburban sections there has been a noticeable trend toward the more permanent structures of brick, stone, concrete, and steel.

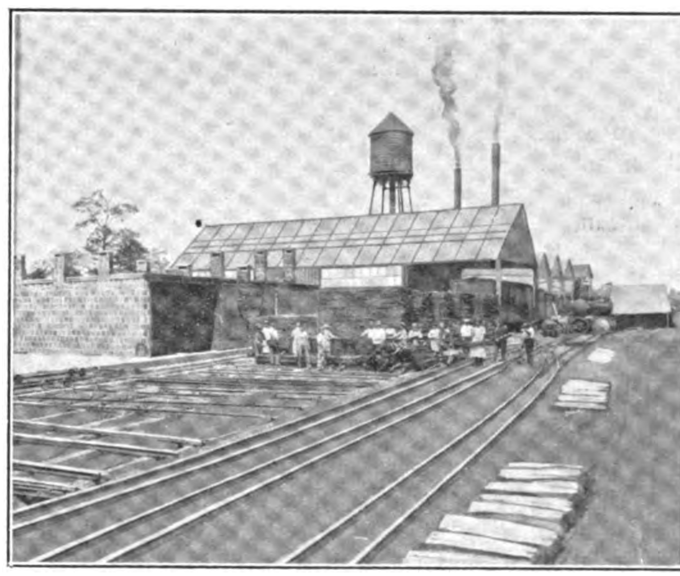
While much of the replacement of wood in the field of building construction has been the direct outcome of modern progress and invention and changing social conditions, it has been influenced in no small measure by the fact that wood is the only primary structural material that is inflammable at ordinary temperatures. It is largely because of this fact that the building codes have been revised in many cities to regulate the use of lumber, lath, and shingles within the more congested zones and in certain types of buildings. The shingle has been most generally prohibited, but in many of the larger cities the legislation has been extended to frame construction of all kinds, while in numerous "fireproof" buildings, exceeding certain height limits, even natural wood flooring and interior trim have been ruled out.

The discrimination against the use of lumber and related products on the grounds of their susceptibility to fire has greatly stimulated a search for suitable ways of making these materials fire-retardant. Such endeavors are not new, however, for even the ancient Greeks were concerned with the problem. During th early part of the last century many experiments were conducted throughout Europe with various and sundry external washes and paints and wood was soaked in all sorts of strange solutions, often for the purpose of rendering it resistant to decay as well as fire. But these early attempts, which were chiefly concerned with superficial coatings, apparently met with little success. It was not until near the close of the century, when suitable methods for thoroughly impregnating wood were devised, that the real development in the practice of "fireproofing" began.

Surface coverings of metal and "fireproof" paints, which serve to prevent the free access of the air to the wood and thus retard combustion, are in fairly extensive use today, but the cost of the former and the temporary effectiveness of the latter have greatly limited their field of usefulness. The greatest development has unquestionably taken place in the practice of impregnating lumber with fire-retardant chemicals, and it is to material treated in this way that the name "fireproof wood" is commercially applied. The term "fireproof" must not be accepted in too literal a sense, however, for, although it may be possible to treat wood so that it will not support combustion at temperatures in excess of 5,000 degrees Fahrenheit, none of the present commercial treatments are so effective.

History of "Fireproofing" of Wood.

The "fireproof wood" industry had its inception in the United States in 1895, when the work was first undertaken in response to a demand for such material in the construction of American warships. The market was further extended in 1899, when the New York City Building Code was amended to prohibit the use of wood for floors and interior trim in all buildings over twelve stories (150 feet) in height, unless it was satisfactorily "fireproofed." The Navy Department early experienced difficulty



Fireproofing Plant of the Protexol Corporation, Kenilworth, N. J. The treating cylinders may be seen at the right and the dry kilns at the left. In the center, treated flooring is being piled on trucks preparatory to kiln drying.

(*Courtesy, Protexol Corporation.*)

with the treated wood, under the damp conditions to which it was subjected on the vessels, and in 1902 discontinued its use. In the dry interior of land structures, however, far more satisfactory results were obtained and the New York City requirements have continued in effect to the present day. In fact, it is these requirements which have been largely instrumental in developing the industry to its present status, for, although various attempts have been made to develop a market in Boston, Philadelphia, and other Eastern cities, New York still continues to absorb the great bulk of the output of the "fireproofing" plants. During the World War, when all non-essential building was curtailed, the industry practically went out of existence, but it was revived in 1919 and has made a steady growth since that time. The past year, particularly, has witnessed a marked expansion in treating facilities, in response to the stimulation of

an enlarged building program in New York and elsewhere. Today there are facilities available in the East for "fireproofing" more than 15,000,000 feet of lumber annually and the completion of several new treating plants, now under construction, will increase this capacity to a marked extent. Considerable interest is also being evinced on the Pacific Coast, although production in that section is very limited as yet.

Chemicals Used for "Fireproofing."

A great variety of chemicals have been recommended as fire-retardants in the past, but comparatively few have been tried out to ascertain whether they would meet the requirements of service. That effectiveness in delaying combustion and retarding the spread of flame is not alone sufficient is evidenced by the failure of some of the most effective chemicals to find favor in the "fireproof wood" industry. The added requirements of reasonable cost, non-corrosiveness, non-hygroscopicity, permanence, and ability to thoroughly penetrate the wood have been instrumental in greatly reducing the list of acceptable substances. So far as the writer is aware, the present day commercial treatments are largely dependent upon three ammonium salts, the phosphate, sulphate, and chloride, although several additional chemicals may be used in some of the newly-devised processes.

These fire-retardant chemicals, when impregnated into wood, retard combustion in one of two ways. Under the action of heat, they either liberate non-combustible gases, which dilute the combustible gases evolved from the wood to the extent of making them non-inflammable, or they fuse over the surface of the material and exclude the air necessary for ignition. Ammonium sulphate and chloride act in the former manner, while the phosphate, which is generally regarded as the most efficient of the three salts, has a dual effect, breaking up into the non-combustible gas ammonia and the fusible phosphoric acid.

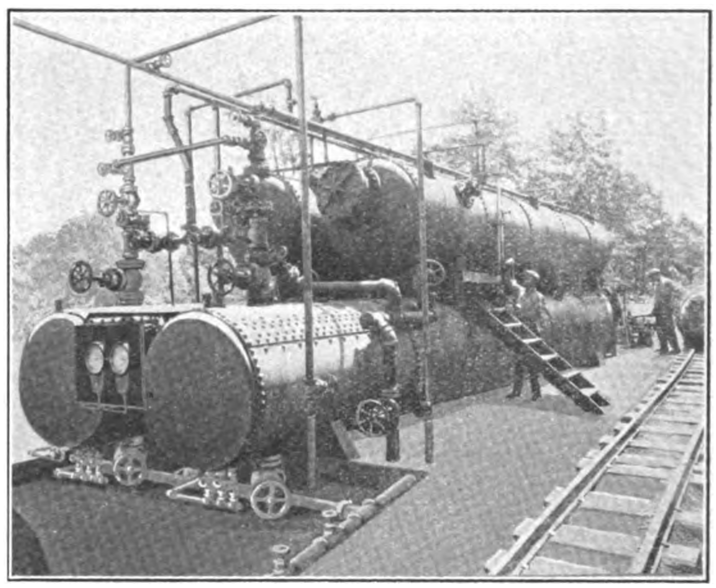
Treatment of Wood.

To be most effective it is essential that the fire-retardant chemicals thoroughly penetrate the wood, and for this reason the commercial treatments are carried on under artificial pressure in closed cylinders, in much the same manner as the treatments for protecting timber against decay. The wood, usually in the form of finished flooring or rough lumber, which is later manufactured into trim or other material, is preferably thoroughly air-dried prior to treatment, although the seasoning may be accomplished in the treating cylinder by steaming the wood under light pressure to heat it thoroughly and then drawing a vacuum, which lowers the boiling point of the contained moisture and hastens the rate with which it evaporates. When this steaming and vacuum treatment is not resorted to, it is common practice to subject the air-dried material to a preliminary vacuum, which tends to remove some of the moisture and air contained in it and facilitates the entrance of the chemical solution. In either case, following the preliminary treatment and without first breaking the vacuum, the fire-retardant salts, in water solution, are introduced into the cylinder until the desired pressure is obtained. This pressure is maintained until the guages, or other measuring devices, show that the desired amount of solution has been injected into the wood. In every case, the practice should be to treat the wood to "refusal," or until it will absorb no more of the solution, for a lighter treatment is not considered satisfactory. Following this impregnation the pressure is broken and the wood is allowed to drip in the cylinder for a while. At times, a slight final vacuum is drawn, in order to hasten the recovery of the solution which is forced out of the wood after the pressure is released.

When the wood is removed from the cylinder it is saturated with the chemical solution and, before it can be used, it is necessary to have it sufficiently dry for the purpose for which it is intended. For flooring and interior trim this means about 7 per cent moisture content and necessitates kiln drying. The material may be run directly into a dry kiln or it may be first subjected to a preliminary air-seasoning; both practices are followed, although the latter greatly increases the drying period. The usual methods of kiln-drying under atmospheric pressure are being used at present, but several processes of drying under vacuum are being advocated in this field. It is claimed that the drying period is greatly reduced in these vacuum systems, but there is as yet no definite assurance that the difficulties that have been evident in the past in vacuum seasoning have been overcome. In either case, the drying of "fireproof wood" is somewhat more difficult than the seasoning of untreated green material and requires a careful adjustment of the conditions within the kiln, in order to remove the desired amount of water and yet not volatilize the chemicals or "pull" them to the surface.

Present Trends in the Industry.

Although the "fireproof wood" industry is now enjoying a decided expansion, the market for its product is rather strictly



Rear view of treating cylinders, showing control valves and guages. Pressure is built up in the superimposed measuring cylinders, forcing the "fireproofing" solution into the wood in the retorts below.

(Courtesy, Protexol Corporation.)

limited today. The outstanding drawback to the more extensive utilization of the material is the cost of the treatment which without subsequent drying, ranges from $50 to $75 per thousand feet and practically precludes the "fireproofing" of framing timbers, sheathing, roofboards, and the other less expensive forms of lumber used in building. The ever-increasing competition in the production of "fireproof wood" is undoubtedly having some effect in curtailing the cost of the product, but it seems improbable that the treating charges can be reduced very drastically under present conditions without approximating the cost of production. The equipment required and the special handling involved in the treatment are expensive at best, and the solution of the difficulty apparently lies in the discovery of an inexpensive chemical which is capable of meeting the imposed

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BERTRAM BORDEN BOLTWOOD

THE sad death of Bertram Borden Boltwood, Professor of Radio-Chemistry at Yale University, occurred August 14-15, 1927, at Hancock Point, Maine. For the past few years Boltwood had not enjoyed very good health.

Those who knew him well liked him for his great personal charm and for his wide acquaintance with things outside of his science. He found good in everybody with whom he came in contact and was always ready to spend his time and his energy to help. He had a great personal influence on students and enjoyed associating with them. In regard to his own work and contribution to science, he was modest beyond comprehension. One looking up Boltwood in *Who's Who* does not learn that he discovered one of the chemical elements, or that he gave us the best method of determining the age of the earth, or that his discovery of chemical inseparability of ionium and thorium is the basis on which a whole branch of science of isotopy has grown, or that his work on the constancy of actinium to uranium relation and its actual value pointed to a "branch" genetic relation of these radioactive elements, etc. What one will find in *Who's Who* is that Boltwood was a contributor to scientific journals—modesty par excellence.

Bertram Borden Boltwood.

Bertram Borden Boltwood was born July 27, 1870, in Amherst, Mass. His father was Thomas Kast Boltwood, Yale B.A. 1864, of English descent, and his mother was Mathilda Van Hoesen Boltwood, of Holland Dutch descent. Many of his relatives are among the Yale alumni. His grandfather, Lucius Boltwood, was active in founding Amherst College and was secretary of its Corporation from 1828 to 1864; he was also the first candidate of the Liberty Party for governor of Massachusetts in 1841. His mother's ancestors were among the early settlers of Rensselaer County, N. Y. His father, a lawyer, died in 1872 in Hartford, and his mother died in Manchester, England, in 1909. His nearest relative surviving is his aunt Albertine Van Hoesen of New York City.

Boltwood's boyhood days were spent at first in Amherst and later in Castleton-on-Hudson and in Albany, N. Y. He prepared for Yale at the Albany Academy. He entered Yale with the class of 1892 S. and registered for the chemistry course. In his Freshman year he received a prize for first rank in physics and in his Senior year he took the highest rank in chemistry in the class and read at Commencement a dissertation on "Iso nitroso cyanacetic ester."

In July, 1892, immediately after graduation, he left for Germany, where he spent two years studying inorganic chemistry at the University of Munich, with special attention given to the Rare Earths, under Professor Krüss. In September, 1894, he returned to Yale and was appointed assistant in analytical chemistry (1894-96) in the Sheffield Scientific School of Yale University. In 1896 he again went to Germany and spent the summer semester at Leipzig University, devoting this time his attention to physical chemistry. On his return to Yale in the autumn of the same year, he was promoted to an instructorship in analytical chemistry and later to one in physical chemistry, in which position he continued until 1900. In 1897 he received his Ph.D. degree, doing his research work under Professor H. L. Wells "On the double salts of caesium chloride with chromium tri-chloride and with uranyl chloride." In the spring of 1900 he gave his lecture on Liquid Air in the Mechanics Course of the Sheffield Scientific School, which attracted unusually great interest among Yale men.

In the Class of 1892 Sheff. Biographical Sketches (1917) Boltwood wrote, "In the year 1900 I severed connection with the Sheffield Scientific School and conducted until 1906 a private laboratory in New Haven. During this period I devoted considerable time to technical chemical work and was for some years associated with Joseph Hyde Pratt,* '93 S., under the title of Pratt and Boltwood, consulting mining engineers and chemists. My interest in the scientific side of chemistry remained, however, and I still continued work in these directions. In 1906 he received an offer of assistant professorship of physics in Yale College, which he accepted and held until 1910. He says in the Class Book, "Although this appointment was in a subject different from the one to which I had chiefly devoted my atten-

* J. H. Pratt is Professor of Economic Geology at North Carolina University.

(*Continued on page 44*)

Research in Mineralogical Laboratory

Investigations Result in New Tests Which Have General Application, Although of Special Importance in Detecting of Elements in Minerals

By Dean Charles H. Warren

DURING the past summer a series of investigations have been carried out under the direction of Dean Warren, who is also Sterling Professor of Geology, in the Mineralogical Laboratory of the Scientific School.

These investigations have been concerned primarily and chiefly with specific tests, in part chemical, in part physical, for certain of the chemical elements, and with the technique pertaining thereto. They are of especial importance in the detection of these elements as they occur in mineral compounds. Their usefulness is, however, by no means confined to mineralogical work, but in many instances has a more general application. The tests throughout have also been developed with special regard to their application to the testing of minute grains so commonly the object of study in thin slices of rocks, or on polished surfaces of ores.

The senior author of the work, Mr. Putnam, while studying with the writer some years ago at the Massachusetts Institute of Technology in Cambridge, Massachusetts, became interested in the methods of determinative mineralogy and devoted considerable time to the subject, with the result that he devised and worked out a new and ingenious system for mineral determination. In the course of this work his attention, like that of all who have occasion to make careful and exact mineral determinations, was drawn to the desirability of increasing the number of precise, specific tests for the various elements and of making improvements in the technique whereever possible. Among other things, the importance of reliable and easily performed micro-chemical tests came in for particular attention.

Arrangement of work bench and laboratory in which work has been done.

At the beginning of the summer, Mr. Putnam outlined to the writer a comprehensive program of further investigation along this line which he desired to carry out. Happily the writer was able to place the facilities of the Yale laboratory at his disposal and to meet the expenses connected with the work by a substantial grant drawn from the research funds attached to the Sterling Professorship in Geology. We were fortunate in securing the services of Mr. Roberts, instructor in Physical Chemistry, and Mr. D. H. Selchow, assistant in Mineralogy in the Scientific School. Mr. Roberts devoted special attention to microchemistry and to heavy solutions; Mr. Selchow to the photomicrography and to the blowpipe tests. We are also indebted to Professor Zeleny and Professor Uhler of the Sloane Physics Laboratory for advice regarding the microspectroscopic work and to Mr. Enerson, mechanic in the Sloane Physics Laboratory, for his skilful work in connection with several pieces of apparatus devised especially for this work.

The investigations fall into the following groups:

1. Micro-chemical tests.
2. Photomicrography.
3. Microspectroscopy.
4. Heavy liquids.
5. Index liquids.
6. Blowpipe tests.
7. Emission spectra.

In the investigations relating to chemical tests, particularly the micro-chemical ones, no expense nor pains were spared in securing reagents of the utmost purity, and every effort was made to define as accurately as possible the conditions, both physical and chemical, in each test so as to give results of known precision and reliability. Particular attention was given to ascertaining the effect and its extent of the presence of interfering elements likely to be present under actual working conditions. Wherever possible, simplicity in technique used was aimed at in order to render the use of the various tests as easy and practicable as possible for geologists or chemists who might be obliged to work under conditions where elaborate costly apparatus was not available and who perhaps had not had an opportunity to develop a highly skilled technique.

The original program of investigation contemplated an exhaustive study of all the chemical elements from the standpoint of micro-chemistry. The completion of this program naturally could not be anywhere near covered in the time at our disposal, but it is felt that a substantial amount has been accomplished along lines which may suggest to others the desirability of extending this line of investigation.

Following is a brief summary of the results secured to date:

1. Micro-chemistry.

New test for Au, S, Se, Te.

Tests for Cu, Co, Ni, Pd, Fe, Mn, Ga and In worked out more satisfactorily than previously.

Methods for opening up the mineral simplified and standardized.

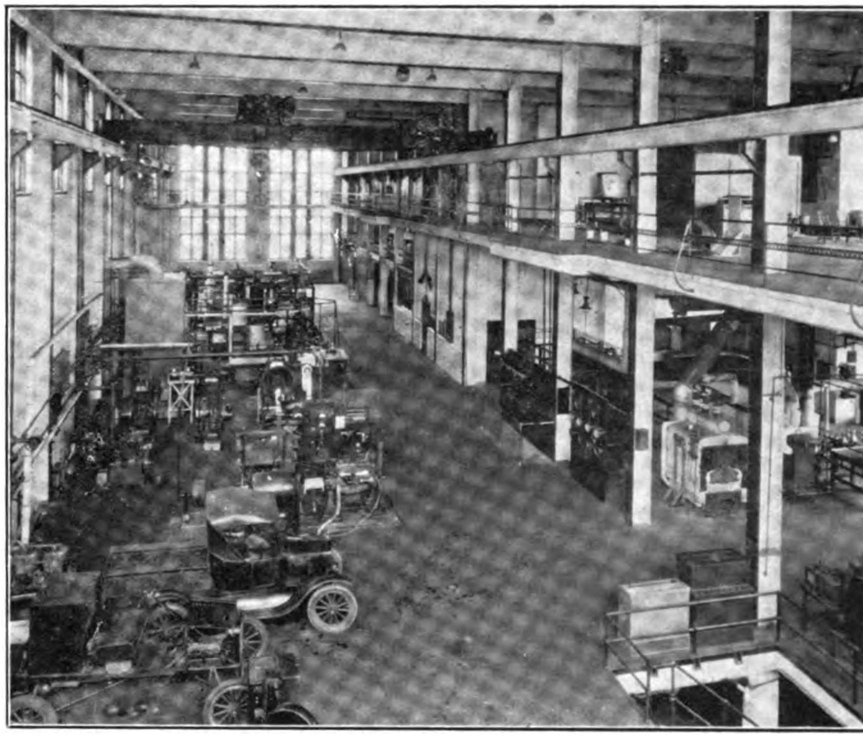
Several new techniques developed—microcentrifuging at 80°-100°, etc.

Field kit designed and made up.

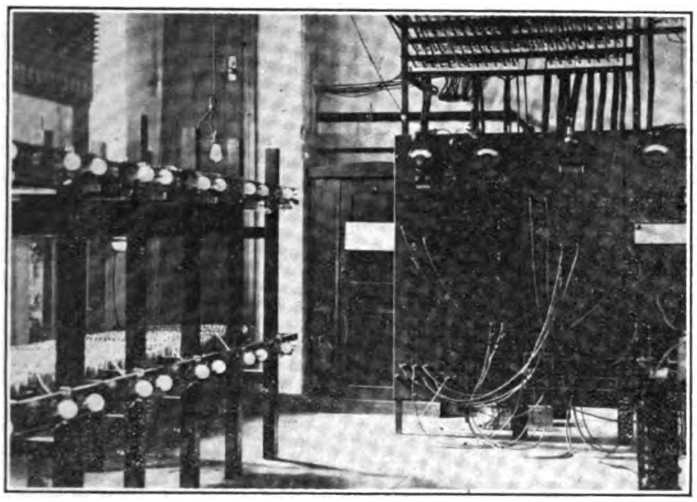
Diamond needle designed for scratching polished sections under medium power.

(*Continued on page 42*)

ABOVE.—*Dr. L. W. McKeehan, newly appointed Professor of Physics and Director of the Sloane Physics Laboratory, who comes to Yale from the Bell Telephone Laboratories.*

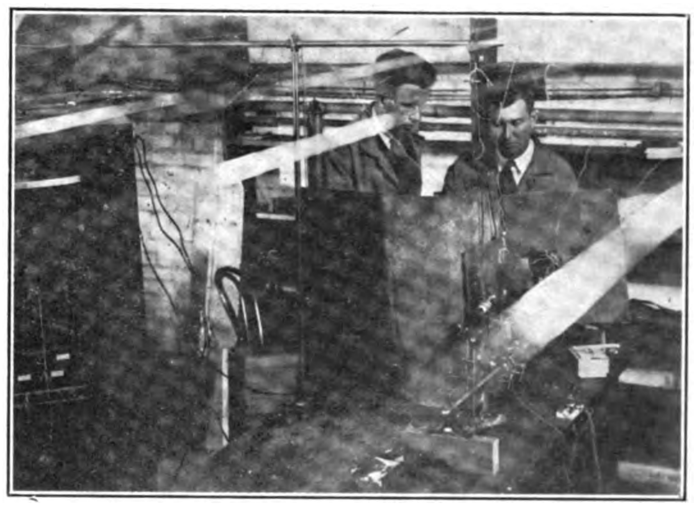


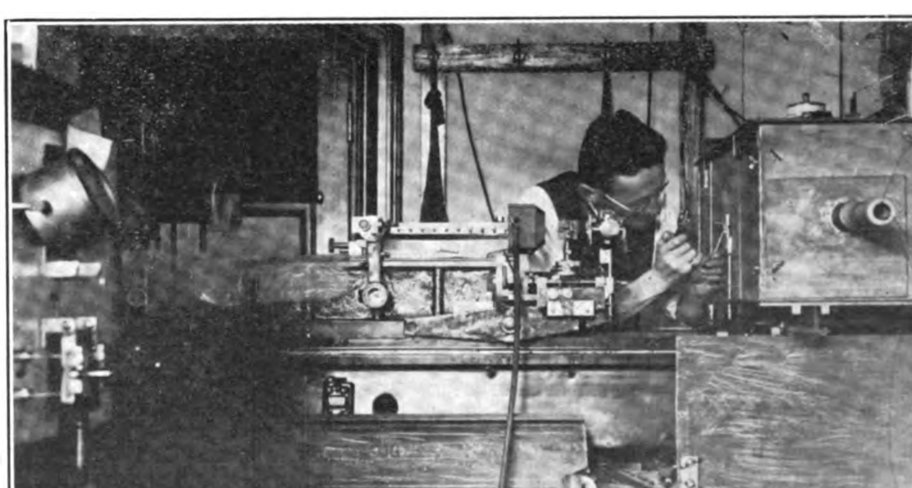
RIGHT.—*View of interior of Mason Laboratory of Mechanical Engineering. The typical units of small size are more economical and are more flexible. They permit frequent replacements by more up-to-date apparatus. T slots in the floor and an overhead crane add greatly to convenience.*



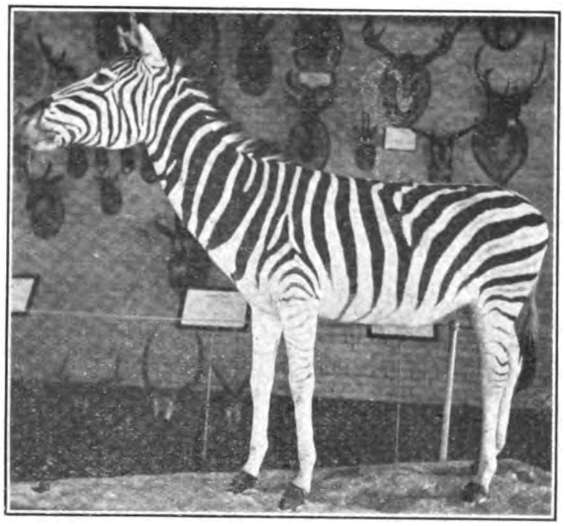
ABOVE.—*New 4,000-volt storage battery in the Sloane Laboratory and switchboard used for distributing lower voltages. Dr. N. Q. Adams of the Physics Department has introduced several novelties in the control of the high potential battery.*

BELOW.—*Dr. E. O. Lawrence and Dr. J. W. Beams, both of the Physics Department, are here seen at work in the Sloane Laboratory on the optical measurements of times as short as a few billionths of a second. The streaks are wires carrying currents producing these effects.*

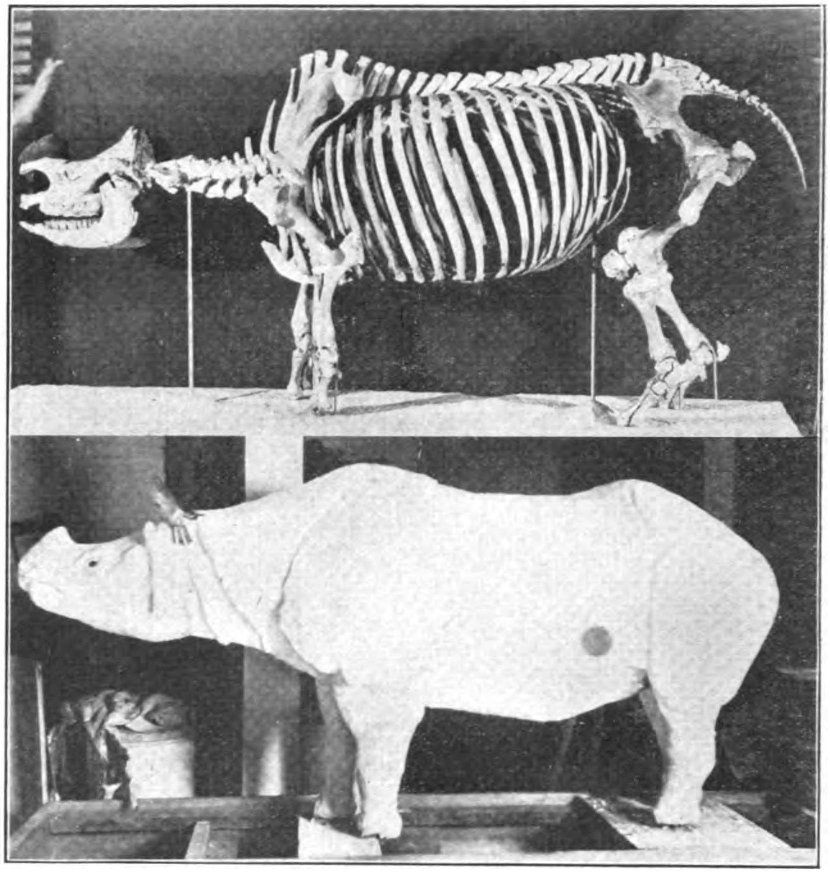




RIGHT.—*Mr. Donald Cooksey at work in Sloane Physics Laboratory. He is adjusting the slits of an X-ray spectrometer of a novel design and of the highest precision. The massive slides and bed-plates prevent the photographic plate from moving except in the one straight line along which its motion can be measured by the peg-studded bar seen beside Mr. Cooksey's right shoulder.*

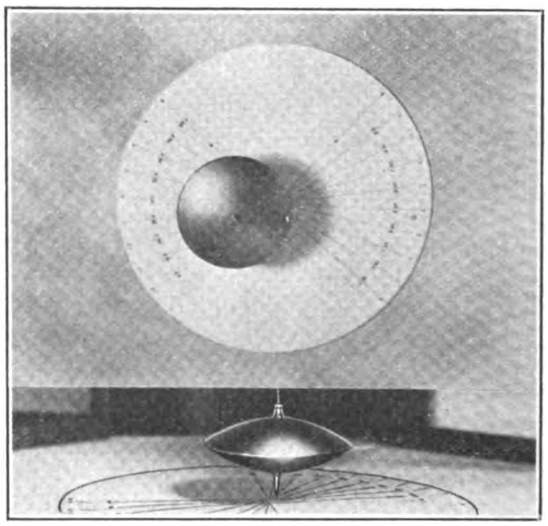


ABOVE.—*Burchell's Zebra, a common species of southern Africa obtained from Ringling Brothers' Circus. The specimen was mounted by Mr. T. A. James at Peabody Museum, who is also mounting the Indian Rhinoceros.*

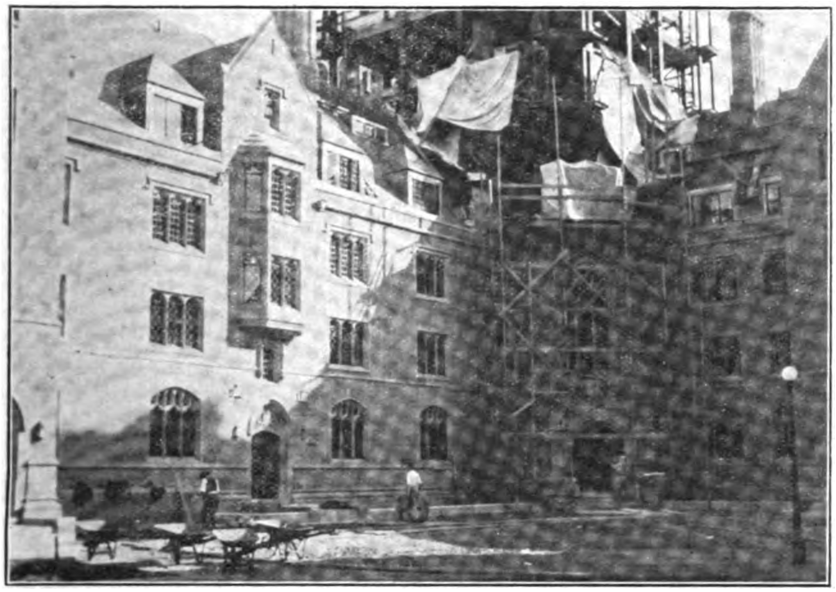


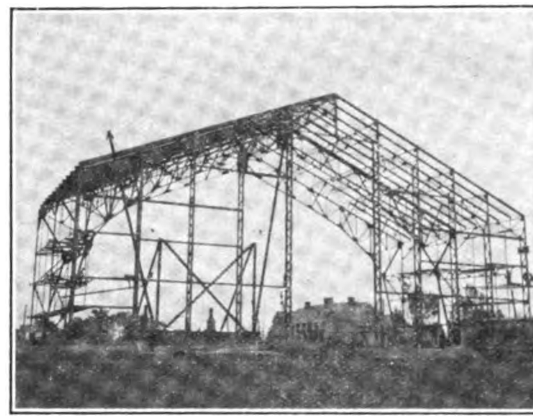
RIGHT.—*"Big Bill," a rare species of Indian Rhinoceros, also obtained from Ringling Brothers' Circus. The photographs show the skeleton and the plaster mannekin upon which the hide is being mounted.*

ABOVE.—*Group of Virginia or White-tailed Deer, in Peabody Museum, recently prepared by T. A. James. These deer, practically extinct in 1800, have become so numerous in the past twenty years, due to protective laws, that they do damage to gardens and young trees. (Fawn, Doe and Buck).*



ABOVE.—*Foucault Pendulum at Peabody Museum. This instrument furnishes direct proof that the earth rotates from west to east. Each day it is set swinging over the zero mark on the dial. As time passes the plane of oscillation appears to turn progressively in a clockwise direction. Actually the pendulum keeps swinging parallel to its original plane, and the apparent change in direction is due to earth rotation. At the pole this apparent deviation would amount to 360 degrees in 24 hours, or 15 degrees per hour. At the latitude of New Haven—41° 18' North—the hourly deviation is slightly less than 10 degrees. On the equator there would be no deviation, and in the southern hemisphere the apparent motion is counter-clockwise. As the hourly deviation varies directly with the sine of the latitude it is possible, by making accurate measurement of the angle, to determine the approximate latitude of the pendulum station.*



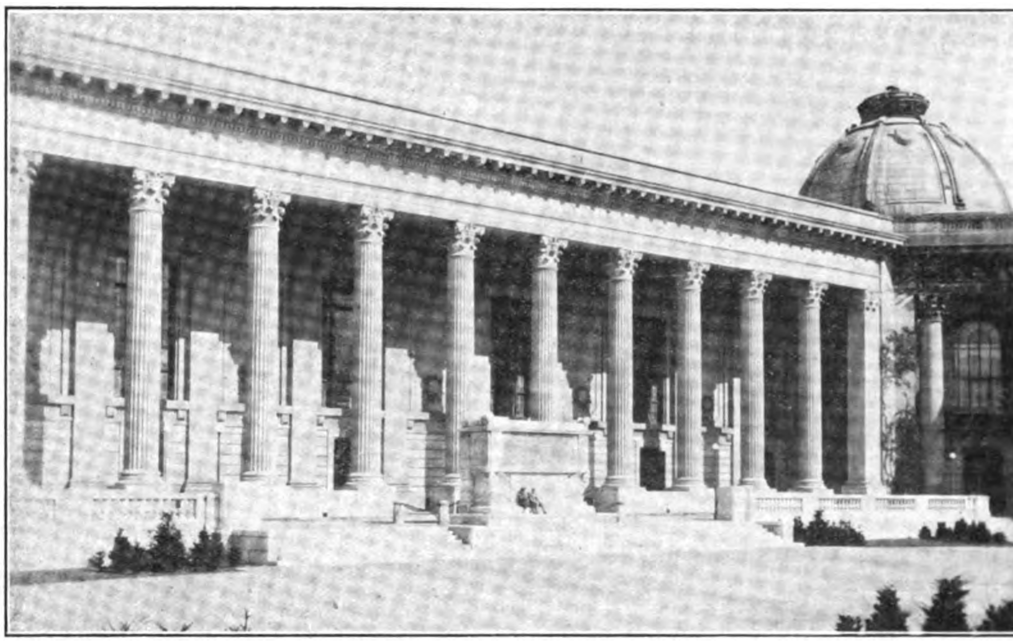


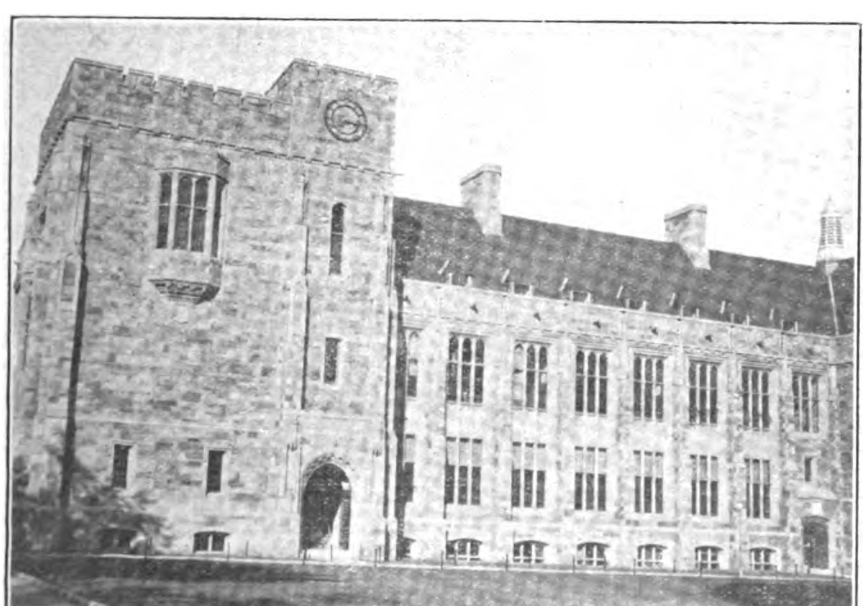
ABOVE.—*Construction on the Coxe Memorial Field Gymnasium is progressing rapidly. The Gymnasium is thegift of the family of Charles E. Coxe, '94, and will provide indoor facilities for football, baseball, track, tennis, and lacrosse. It will be completed early in 1928.*

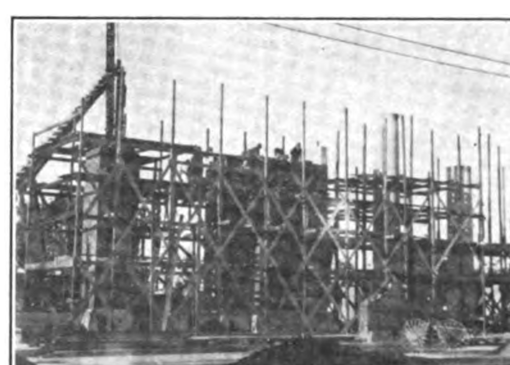
ABOVE.—*Bingham Hall, the gift to the University of the sons and daughters of Charles W. Bingham, '68, is rapidly nearing completion. Two wings are at present occupied.*

RIGHT.—*The University Memorial Collonade, a tribute to the Yale men who died in the War, was dedicated Sunday, June 19.*

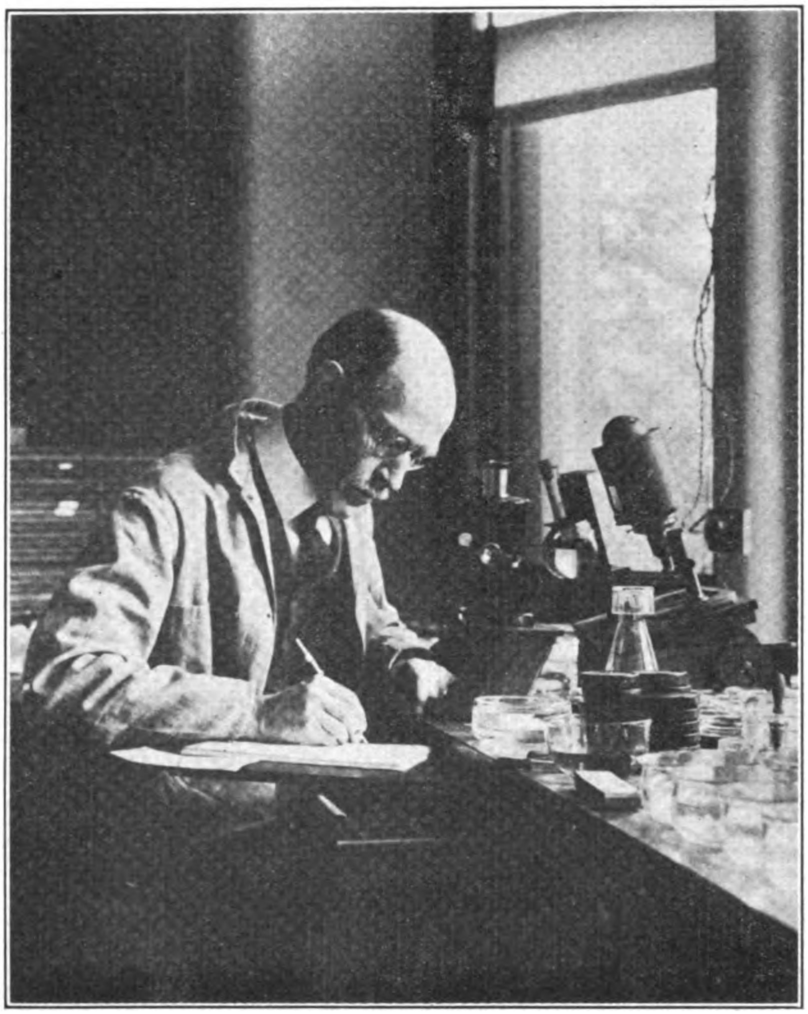
BELOW.—*The William L. Harkness Recitation Hall, which was dedicated Saturday, November 5. The exercises were attended by Mrs. Harkness and her children, Mrs. Louise Harkness Ingalls and William H. Harkness, 1922, who formally turned over the building to President Angell.*

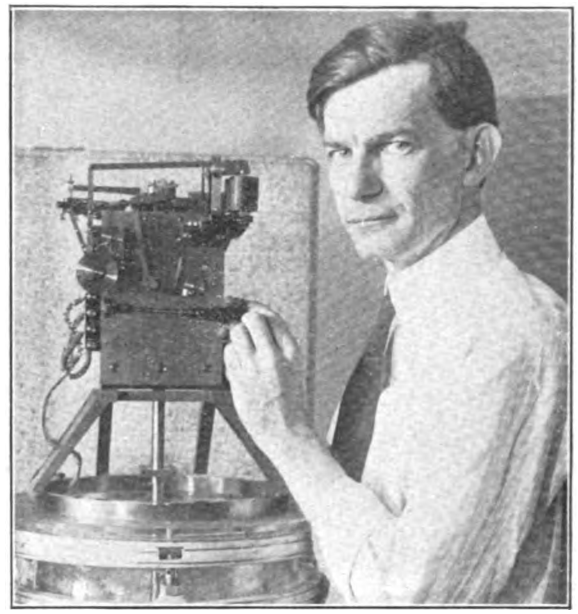






ABOVE.—*The Walter Camp Field Memorial, built by gifts from Yale Alumni and the universities, colleges, and schools of the United States. No date for dedication has been determined as yet, but the work is nearing completion.*

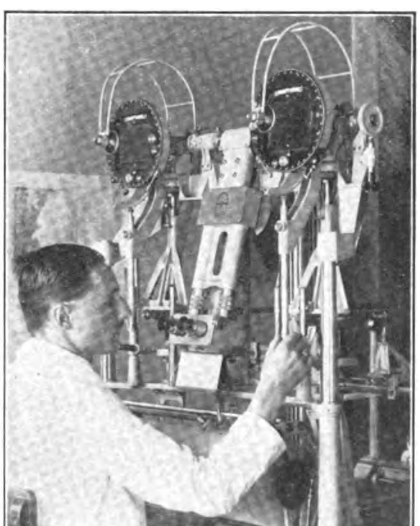




(Photo by Underwood)

ABOVE.—*Experiments now being conducted by Paul Sollenberger at the U. S. Naval Observatory on a precision clock which allows the pendulum to swing free most of the time and uses electrical impulse so as not to disturb the pendulum's operation.*

LEFT.—*Prof. Ross J. Harrison, Director of Osborn Zoological Laboratory and world famous zoologist, who is here shown with his experiments on transplantation and regeneration of amphibious larvae, is at present taking a sabbatical year in Europe. Recently he lectured before the International Zoological Congress at Budapest and now expects to carry on experimental work this winter at the Marine Biological Station at Naples.*



(Photo by Underwood)

ABOVE.—*Trials of a German-made aerocartograph are now being made by the U. S. Geological Survey. The aerocartograph is expected to effect savings in the making of topographic maps, especially where rugged mountains or dense forests have made mapping difficult. Photographs of strips of land are re-projected on map surfaces so as to indicate the topography in detail.*

ABOVE.—*The Yale Naval Unit taken on board the U. S. S. Florida during its first summer cruise. The ship sailed from New Haven on June 16th with 23 men in charge of Commander L. B. Green, 2nd, for Annapolis, Savannah, Newport, and Boston. During the two weeks that this trip consumed, navigation, seamanship, ordinance, and engineering were taught.*

Metal Structure Revealed by New Methods

Clearer Understanding of Behavior of Metals and Alloys Results from Use of Sensitive Micro-chemical and Spectroscopic Tests

By Prof. C. H. Mathewson, 1902S

DOUBTLESS the scientific study of metals and alloys began in the chemical laboratory. The early methods of compounding or alloying metals gave rise to products whose identity could of course be determined by chemical analysis. Unfortunately, however, knowledge of the ultimate chemical composition of a metal product does not inevitably constitute an adequate basis for judging the quality or performance of that material in its intended service. Thus, a very pure metal may be deficient in strength owing to a porous or unsound condition, as in Figure 1, or an alloy of quite suitable composition may be defective because some normal constituent has acquired an unfavorable form or distribution, as in Figure 2, through faulty heat treatment.

To the casual observer, the nature and performance of any substance are clear reflections of its chemical composition and this observation is indeed justified, somewhat in proportion to the accuracy of the chemical analysis. Recent metallurgical experience is teaching us that almost unbelievably small amounts of impurities, or certain metals intentionally added to certain alloys, may vitally affect the properties under examination. We can no longer without investigation complacently tolerate even a few thousandths of a per cent of any haphazard impurity in many special products. In some cases, the impurity, or added metal, combines chemically with a definite quantity of the predominant metal which, in reality, greatly magnifies the percentage of foreign substance present. Thus, one hundredth of a per cent

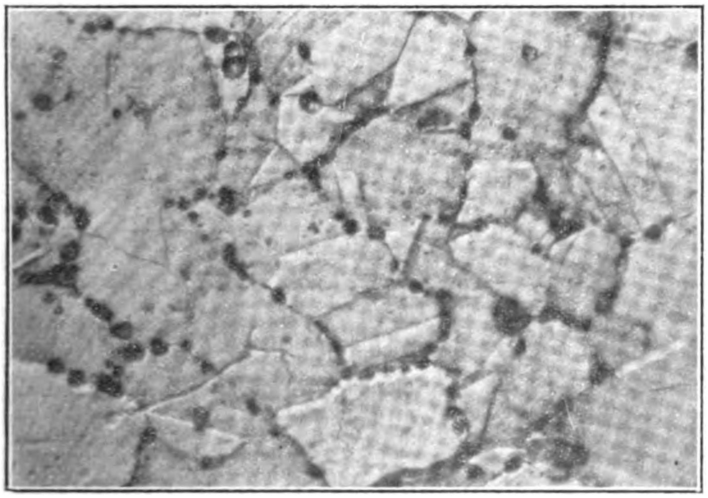


Fig. 1. Gassed or Porous Copper.

of calcium added to lead appears as the compound $CaPb_3$ amounting to nearly one-fifth of a per cent of the entire alloy. In other cases, the added impurity may assemble in the form of minute films surrounding the inner structural units of the material and interfere with their cohesion. Thus it is said on good authority that one part of bismuth to 4,000 of gold makes the latter brittle and unfit for use. Probably a much smaller quantity of bismuth would seriously impair the ductility of gold.

Much attention is now being directed to a class of alloys which harden and strengthen on standing after a suitable preliminary treatment. Duralumin, the first and most celebrated of these alloys, is extensively used in aircraft construction. Copper, silver, lead and other metals have also been age-hardened and the process, which is essentially a controlled internal precipitation of previously dissolved alloying material, is, in some cases at least, extremely susceptible to modification by certain impurities in minute quantity. The antimonial lead used for sheathing toll line telephone cables hardens, and may later soften, under

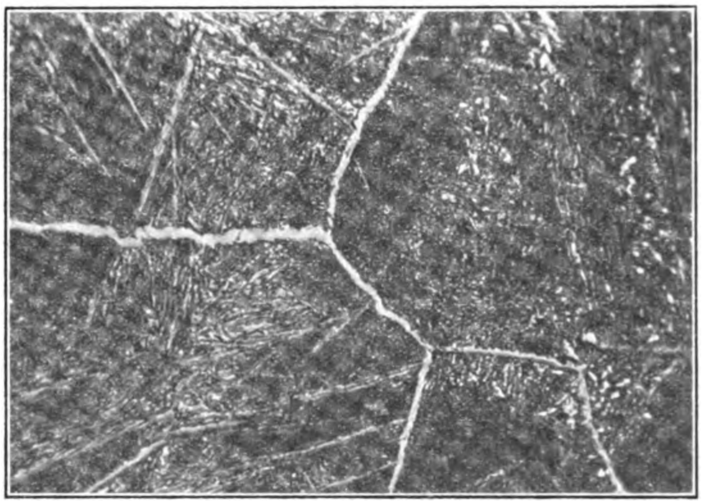


Fig. 2. High Carbon Steel in a faulty structural condition. Shows coarse grains enveloped by iron carbide (white), a hard and brittle constituent which should be present in the form of fine particles instead of coarse patches.

the temperature-stress conditions encountered in the field. Great care must be exercised in selecting lead which will meet the exacting requirements of this service.

The porous metal illustrated in Figure 1 also carries a burden of uncertainty as to its exact composition which would be difficult to dispel by any ordinary analytical treatment. The cavities in porous metal may be vacant, having formed as a result of unequal contraction in different parts of the structure, or they may contain gas set free as a result of changing equilibria during solidification. In any case, the amount of gas is small and difficult to detect. This is one of the most fertile of all experimental fields in the investigation of metals and many laboratories are engaged in acquiring facts or using the underlying principles of physical chemistry to aid in perfecting an art of producing sound, dense metal.

The above illustrations will suffice to indicate the very precise nature of the chemical requirements demanded in the scientific study of metals and alloys. To meet these requirements the ordinary methods of the analytical laboratory are being supplemented by very sensitive micro-chemical and spectroscopic methods.

A great fullness of research during the last quarter century has dispelled most of the mysteries concerning the changes which

may be produced in metals and alloys by working them under various fabricating conditions or by annealing, quenching and tempering them according to common practice. Direction and impetus were given to this work by the discovery on the part of physical chemists and a later appreciation on the part of metallurgists that the wonderful studies made by J. Willard Gibbs, perhaps the most distinguished of Yale's scientific sons,* on principles of equilibrium between the various constituents (phases) which may appear in a mixture of designated components, could be applied in systematizing the whole range of possible structural conditions in every possible combination of metals.

It must not be inferred that one may write down in advance without experimental guidance a precise characterization of the structural units which will be encountered in any chosen mixture of metals. It is necessary in each case to obtain appropriate data which are then assembled according to the system originating with Gibbs in the form of a so-called constitutional diagram. These diagrams are virtually maps of their respective alloy systems, in which fields are blocked out to represent the respective ranges of temperature and composition throughout which particular forms of the alloy persist. For example, ordinary yellow brass, a copper-zinc alloy containing about 65 per cent of copper, is molten at all temperatures above approximately 930° C. When cooled down, it solidifies throughout a range of falling temperature amounting to some 25°C. and during this time is located within a constitutional field calling for the simultaneous presence of liquid and solid brass. At the last stage of freezing there is a reaction between the liquid and some of the solid brass already present to form a new kind of solid and the alloy thereupon enters a field devoted to the simultaneous presence of these two kinds of solid brass. Although the brass is now completely frozen it does not remain inert, but on further cooling one of the solid forms grows at the expense of the other, until at a temperature somewhat below 700°C. the brass finally enters a field occupied by a single solid form.

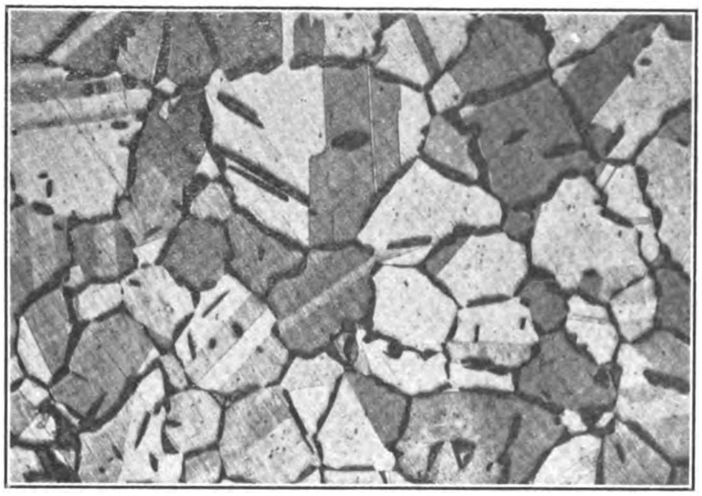


Fig. 3. Yellow brass heated to bright redness and rapidly cooled. Unsuitable for deep-drawing or forming operations because the grains of the soft constituent are surrounded by more or less continuous walls of a relatively hard and brittle constituent.

The practical value of this kind of information is at once evident. Scores of constitutional diagrams have been worked out in recent times, with the result that a very comprehensive literature for reference in this field is now available. This supplies what is now rather generally regarded as an indispensable starting point for almost any kind of an investigation with alloyed metals.

Broadly speaking, the systematic information which is woven into these constitutional diagrams stops short of perfection in two main directions. In the first place the changes in equilibrium which occur as we pass from one field to another are not automatic and instantaneous. Time is required for these readjustments and the diagram itself leaves us totally uninformed in this important respect. A structure which normally occurs in an alloy at an elevated temperature may often be retained by very rapid cooling (e.g., quenching in water) although it would normally be replaced by a totally different structure on slow cooling. In some cases a partial or interrupted change, giving rise to intermediate structures and properties, occurs on rapid cooling. This is the scientific basis for consideration of the many varied and useful effects of heat treatment.

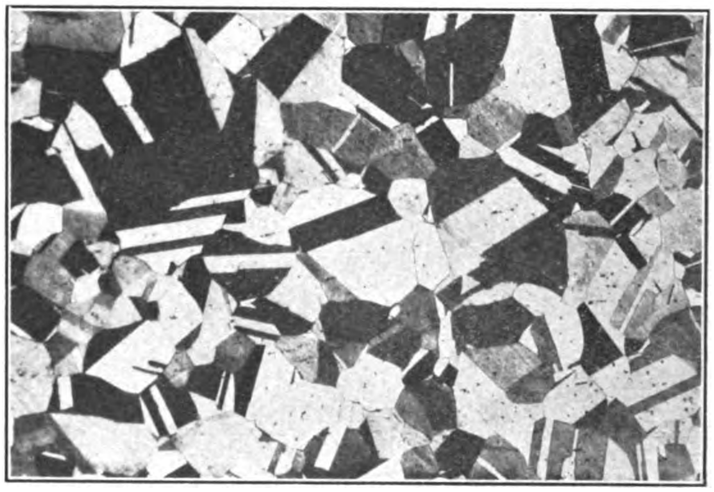


Fig. 4. Yellow brass heated to bright redness and slowly cooled. Normal structure for deep drawing, composed of variously oriented grains of a single (plastic) constituent.

Turning again to the yellow brass used as an earlier illustration, Figure 3 represents the structure of this material heated to 800°C. and quenched, and Figure 4 represents the same material slowly cooled from this temperature. Rapid cooling in the first case has caused the second solid to remain as (black) envelopes around the large grains of the first solid, somewhat damaging the metal for most fabricating purposes. Slow cooling in the second case has caused a normal return to the simpler structure composed of variously tinted grains of the soft and ductile variety known as Alpha brass. The scientific study of alloys in a thoroughly modern sense has produced literally hundreds of investigations, both theoretical and practical, dealing with similar relationships between structure and properties in different alloys produced under different thermal conditions.

Altogether the most favored and fruitful present day type of investigation in the field of metals and alloys is directed towards a group of problems which deal with the innermost structure and attendant behavior of the individual crystalline particles whose interrelationships and conditions of co-existence alone are prescribed in the familiar diagrams. It may be argued that this second deficiency of the conventional constitutional diagrams has supplied the incentive for renewed activity in metal research, bringing new methods and additional talent to bear upon these problems of common interest in physics and metallurgy.

(*Continued on page 42*)

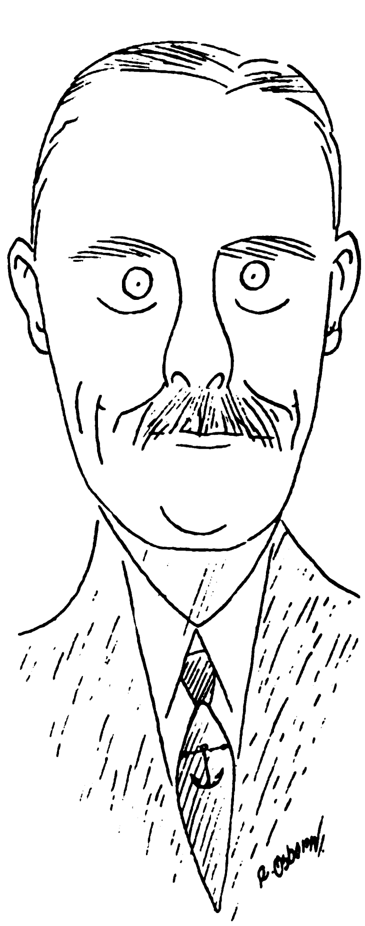
* Every Yale man interested in science would enjoy reading the published account of exercises recently held at the Graduates Club of New Haven in celebration of the fiftieth anniversary of the publication of Gibbs' work on the equilibrium of heterogeneous substances.

P·E·R·S·O·N·A·L·I·T·I·E·S

No. 2. *PERCY TALBOT WALDEN*

It is an oft-heard lament today that the Universities are lacking in men whose personalities can inspire the student. But the dean is not to be included in this. Weak or strong, inspiring, hateful, lovable, irritable, he will always have a personality. If lacking in one when he assumes the office, the student very obligingly creates one for him. Unfortunately, however, this personality is too often built up from rumor and prejudice, and we find some strange monster, some Frankenstein of student creation, occupying the place of dean. There comes occasionally to the office, however, a man whose personality is strong enough to establish its rightful place in undergraduate eyes.

All of us here now will admit that when as Freshmen first we came to Yale we were half ready to create the conventional monster. We were filled with suspicion of the unknown and the youthful distrust of constituted authority. The Dean could not be right if he were Dean. Then we came to know Percy T. Walden and perceive his personality.



Gradually by that mysterious process by which student opinion is formed, we came to the realization that our Dean was a man, a thing of flesh and blood rather than sinister shadow. No need to create a personality here—we had one ready formed to grasp. To feel it, one had merely to have that boyish smile explode before his eyes or meet that understanding gaze beneath the shaggy brows. If the smile faded out for some of us and the gaze grew set and hard or even a little ferocious, it only added to our respect. There was always sufficient cause.

But those of us who failed or escaped personal contact with Dean Walden still came to perceive him. No one can pass through the Common Freshman Year without realizing the wonderful energy of the man. One gains the impression of a vast power, a great vitality, an inherent vigour, all under conscious control. He seems possessed of a dynamic calm (if such a contradiction in terms may be allowed), dynamic because it had the possibility of bursting forth in a passionate storm, calm because the storm seldom broke. The life of Dean Walden can only be explained in the light of this great energy which has given him the capability to meet any task and work out any problem to a solution despite handicaps or obstructions.

Percy Talbot Walden was born on June 29, 1869, at Brooklyn, N. Y., where he resided until he entered the Sheffield Scientific School of Yale University in 1889. Here were formed many of the lasting friendships, which have proved such a constant joy to him ever since. Here he became absorbed in that most interesting and important of sciences—chemistry—and was eventually persuaded to take it up as his life work. With three years of hard work behind him, he was graduated with a Bachelor of Science degree in 1892, taking one of the highest honors, that of Senior Appointments.

After graduation, Dean Walden continued his work in Chemistry with a graduate course at Yale. His research at this time led him into special work in the metals, principally iron, sezium and rubidium. He delved into the mysteries of the double and triple salts of iron, and unearthed much valuable information. In 1896 he received his degree of Doctor of Philosophy.

This compelling love of probing into the unknown and his expanding energy would give him no rest, however, and in 1900, he journeyed to Germany, where he studied for a year in Leipzig and Munich. It was in Germany that Dean Walden did his most extensive research, working in conjunction with Wisleshen and Bayer, two distinguished scientists.

Feeling himself thoroughly equipped, he now turned his energies in the direction of teaching, and it was in 1901 that he became an assistant professor in the Chemistry Department of Yale University. His marriage to Sarah Scoville Whitelsy was solemnized on June 22, 1905. The year 1920 saw him appointed full professor.

In 1924 he was made Acting Dean of Freshmen and his energies expanded to keep pace with the enlargement of his field of activity. So ably did he meet the many perplexing problems facing him in this office that he was named Dean the following year. Since then he has handled the problems of the Freshman Year in a manner characteristic of his training. He has viewed the Common Freshman Year as he would an experiment in his science of chemistry. The conditions must be properly controlled to assure the results and if it has taken painstaking study to learn how the conditions can be controlled, he has not grudged the work. He has not only raised the standard of the Freshman Year, but has found the time to take a deep interest in the extra-curriculum affairs of the student body. His creation of an efficient Freshman Student Council is one of the most outstanding of his many notable achievements as Dean.

As a lecturer in Freshman Chemistry, Dean Walden is unique. He demands rigid attention to the subject matter of the course, and, the remarkable fact is, that he gets it and holds it without using trickery. He is there to teach Chemistry and not to entertain. Yet, when there is a chance to drive something home with a peculiarly striking experiment, he is not above staging it in an effective way. It always seemed as if he took a sort of mischievous delight in bouncing half the class off their seats by proving to them beyond a question of a doubt that hydrogen and oxygen are explosive when mixed in the proper proportions.

The reaction of a one-time Freshman to contact with Dean Walden will probably serve to illustrate the way his personality impresses itself on the student as well as anything else. Following a visit to the Freshman office occasioned by overcutting, that Freshman announced to all and sundry his firmly established conviction that Dean Walden was nothing but an "Old Walrus." Later on in the year, the same Freshman came across a picture of the "Old Walrus" in the Year Book. He gazed at the picture, looked off into space for a moment and then mumbled, "Gosh, but he's a good guy."

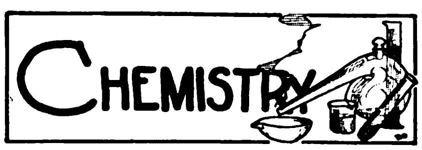
(*Continued on page 50*)

LABORATORY NOTES

The American Astronomical Society, which meets twice a year, is to hold its winter meeting at New Haven, on the invitation of Yale University Observatory, on December 29 and 30. The American Section of the International Astronomical Union, which meets once every third year, will also hold its next meeting in New Haven, on the thirty-first of December.

In 1866, Mr. Joseph Earl Sheffield presented a fine nine-inch telescope to the Scientific School. For more than sixty years this was mounted on the tower of old Sheffield Hall under a cylindrical shelter that many people seem to have mistaken for a water tank. Last spring the telescope was dismounted and stored and the cylindrical shelter removed from the top of the tower. Through the generosity of the donors of Bingham Hall, now nearing completion at the corner of College and Chapel Streets, a fine dome is being erected on the roof of that building, and the Sheffield Telescope will be installed under it. The telescope will be used chiefly for instructing undergraduate students.

Dr. Dirk Brouwer of the University of Leiden, Holland, is spending a half year at the Yale Observatory as a Fellow of the International Education Board.



Dr. R. J. Anderson has been appointed Professor of Chemistry.

Mr. E. J. Roberts and Dr. L. E. Steiner have been appointed instructors.

Prof. C. R. Hoover lectured at the Laboratory on October 19, on Catalysis and Our Liquid Fuel Supply.

Prof. Vandame is in charge of editing an edition of the entire works of J. Willard Gibbs.

Research.

Among numerous subjects which are being investigated, the following may be mentioned:

Prof. Dodge, in co-operation with the Mellon Institute of Pittsburgh, is working on the reactions between gases at extremely high pressures. The yield of organic liquids obtained is of possible importance in connection with liquid fuels. The whole problem of converting coal either directly or indirectly into a liquid fuel is one of the outstanding chemical problems of today.

Prof. Curtis, who has long been interested in the so-called "low temperature carbonization of coal," by which an anthracite-like substance is produced from bituminous coal, is engaged on some of the fundamental chemical problems connected with the process and with the liquid by-products produced in the process. They are entirely unlike the by-products produced in the manufacture of coke.

Dr. C. E. Suter, on the Metz Fellowship, is continuing work carried on last year by Dr. Gatewood, on organic sulphur compounds having medicinal value.

Dr. H. N. Moyer, on a National Research Council Fellowship, is working on the assimilation by bacteria of organic sulphur compounds.

Prof. Richard S. Lull has returned from six months' sabbatical leave spent in Europe, where he investigated geology museums of important centers.

Prof. C. R. Langwell was engaged during the past spring and summer in completing his geology investigations in Nevada.

Prof. C. A. Dunbar spent the corresponding time in geological investigations in Kansas, Oklahoma, and Texas in the vicinity of the oil fields.

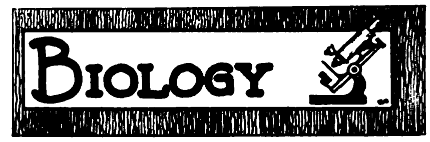
Prof. W. E. Ford spent the summer at Cape Cod and has been engaged in revising Dana's "System of Minerology."

Prof. C. H. Warren had a busy crew, consisting of Messrs. Pulwa, Selchow, and Roberts, engaged in minerology research. Several entirely new methods of minerology investigation were discovered.

Prof. A. M. Bateman spent the summer in the mining regions of Alaska, where he was investigating the application of geophysical methods for the detection of mineral bodies.

Prof. W. M. Agar has been engaged in the study and mapping of the geology of northwest Connecticut. He has just published through the State Survey a bulletin on the geology of the Shepaug Aqueduct tunnel.

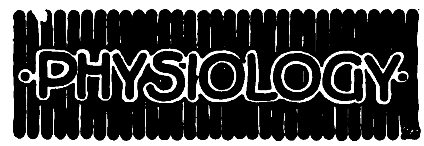
Dr. Richard F. Flint has been making a study of glacial geology of Connecticut during the summer, and in this connection the sand and gravel deposits suitable for road construction and other commercial uses are being outlined.



Prof. R. G. Harrison, Sterling Professor of Biology, is spending his sabbatical year at the Naples Zo-ological Station in Italy.

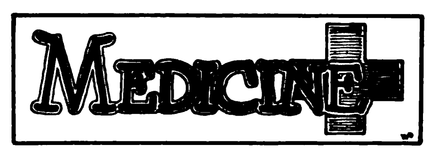
Dr. Woodruff is Vice-Chairman of the Division of Biology and Agriculture of the National Research Council for this year.

Prof. W. R. Coe has recently returned to the University after having taken his sabbatical leave at the La Jolla Biological Station in California.



The American Chemical Society recently published a book, "Noxious Gases," by Professor H. W. Haggard and Professor Y. Henderson of the Department of Applied Physiology. The book, which deals with the physiological effects of noxious gases, is a unit of the monograph series of the American Chemical Society.

Prof. Haggard is at present engaged in compiling material for a text book to be used in his course in Industrial Physiology.



Two additions to the staff of the Laboratory of Physiological Chemistry have been made: Dr. Alfred T. Shohl as Research Associate and Mr. Harry M. Vars as Instructor.

Dr. Francis G. Benedict of the Nutrition Laboratory of the Carnegie Institution in Boston will establish a metabolism unit in this Department to collaborate in certain nutrition investigations in progress here and at the Connecticut Agricultural Experiment Station.

Dr. Mary E. Reid, Sterling Fellow, is making a study on the nitrogen distribution in plants under various nutritive conditions.

The study of the relation of various diets to the chemical nature of body fat and the physiology of its formation is being continued by Mr. W. E. Anderson.

(Continued on page 48)

Civil Engineering

The autumn inspection trip of the Senior Class in Building Construction worked out particularly well this year. In New York City and the immediate vicinity there were under construction some very representative buildings, such as that for the New York Life Insurance Company, the New Equitable, and several excellent industrial jobs, all of which were visited under the auspices of the general contractors in charge of the work.

One of the most interesting visits was that made to the Cathedral Church of St. John the Divine. The verger conducted the party through the completed portions, giving a most complete history of the seven chapels with a most detailed explanation of the architectural treatment. Mr. Cram's representative then became the guide for the sections of the Cathedral still under construction. Sharply contrasted with the great steel skeletons of lower New York, this monumental building is an example of masonry construction employing no steel except for the purpose of framing temporary scaffolds.

This year the class was particularly fortunate in receiving a most intimate talk from Mr. Thomas Hastings given in the reception room of his offices on Vanderbilt Avenue. Another interesting call was made in the office of McKim, Meade and White, where Mr. Lawrence White described the work of the firm.

As has been the custom in past years, the latter half of the two weeks period allowed for the trip was largely devoted to visiting material plants such as the Sayre-Fisher Brick Yard and the Stone Finishing Shop of the William Bradley Company. A few hours on the last afternoon were devoted to the Museum of Art, where the new rooms in the "American Wing" received particular attention.

Electrical Engineering

A Conference on Electric Heat Treatment of Metals is being arranged for November 30 by the Electrical Engineering Department. The requirements in heat treatment, the suitability of electricity for meeting these requirements and a report of the results which are now being accomplished will be presented. Invitation to representatives from the industries of Connecticut and other New England States will be extended by the Manufacturers' Association of Connecticut.

Sixteen officers of the Army and Navy are enrolled in the Graduate School in Communication Engineering. Two of these have already completed their work except essays which they are preparing for the Master's degree in absentia. There are ten other graduate students in this Department.

(*Continued on page 48*)

Mechanical Engineering

Lauren E. Seeley, Instructor in Mechanical Engineering, spent the past summer engaged in experimental research in heating boilers for The H. B. Smith Company, Westfield, Mass., and will continue similar experimental work at the Mason laboratory during the college year.

Some of the Mason Laboratory staff are now investigating a fundamental motor car problem; namely, the discomfort produced by vehicular vibrations. Mr. F. W. Keator is designing a machine which will produce definite vibrations whose relative discomfort can be measured.

(*Continued on page 48*)

Mining and Metallurgy

Professor C. H. Mathewson will deliver the annual Institute of Metals lecture before the American Institute of Mining and Metallurgical Engineers in February, 1928.

Professor Robert K. Warner, after finishing his work on the Mining Methods Section of Peele's Mining Engineer's Handbook, spent most of July and August studying mining conditions in the two lead districts of Missouri and on the Gogebic and Marquette Iron ranges. This fall Professor Warner attended the Empire Mining and Metallurgical Congress during the course of which almost all of the metal producing districts of Canada were visited. About four hundred prominent mining engineers and metallurgists from all parts of the British Empire and the world composed the Congress, whose itinerary totalled about ten thousand miles. Yale was the only American mining school to be represented in the Congress.

Professor Arthur Phillips published a paper in the September issue of the *Journal* of the Franklin Institute on "An X-Ray Study of the Beta Transformation in Copper-Zinc Alloys."

Professor Behre attended the meeting of the American Institute of Mining and Metallurgical Engineers, held at Salt Lake City in August. During his trip west he also visited mills and smelters in the vicinity of Salt Lake City and in Butte and Anaconda, Montana.

Forestry

Dean Henry S. Graves of the School of Forestry, for the past two years has been co-operating with the National Academy of Sciences on the problem of forestry research. He has specialized in the educational aspects of research, visiting the well-known schools in Europe in 1926 as well as the various forestry schools in this country. He is also engaged in preparing books in Forest Economics and Forest Policy.

Mr. Ralph C. Bryant, Manufacturer's

(*Continued on page 48*)

Mathematics

The Department of Mathematics is pleased to report that mathematics is considered favorably by Yale undergraduates. This is shown, in the first place, by the fact that more than half of the entering class continues to elect Freshman Mathematics. In the second place, the number of men electing mathematics in the Junior and Senior years is increasing. Last year the department offered, for the first time in several years, a course in Advanced Algebra. Under the guidance of Dr. L. T. Moore this course was well received and this year it is being repeated. In addition, a course in Geometry is being given by Professor Tracey. The total enrollment in these two elective courses is almost twice as great as that in the one course offered

(*Continued on page 48*)

Physics

Mr. Henry T. Sloane, Yale '66, who with his brother, Mr. William D. Sloane, donated the Sloane Physics Laboratory, has recently given the Physics Department the sum of $26,000 for the purchase of additional equipment.

Mr. R. J. Seeger, '24 Rutgers, has won by competitive examination the $1500 Loomis Fellowship in Physics for the year 1928-29.

Dr. E. L. Kinsey, of Johns Hopkins University, a holder of a National Research Council Fellowship, is engaged in the Sloane Physics Laboratory on an investigation of the resonance spectrum of sodium.

Prof. A. T. Waterman of the Physics Department is in London on leave of

(*Continued on page 48*)

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

THE conclusive evidence compiled by Mr. Crawford through his recently organized Bureau of Personnel Research is the most constructive step that has yet been taken towards the solution of the problems of Sheff under-population and college over-population. He has shown beyond reasonable doubt that the decline in enrollment has been due to influences exerted prior to matriculation and cannot be laid to the Common Freshman Year, whose introduction coincided so guiltily with the arise of the population problems. As a result we find, along with the other organizations that have been naming the Common Freshman Year as the chief source of their trouble, that we have been putting our emphasis in the wrong place.

Prior to Freshman Year! The problem is now much more complex. It is more serious. It is more fundamental. It cannot be solved by a stroke of the pen. We must not hesitate to take advantage of the good steer Mr. Crawford has given us, and apply ourself more diligently to its solution. It is safe to say that it is the resultant of a dozen adverse influences in which we may include the admitted trend towards the arts and specialized commercial training such as the college courses permit.

The statistics show that in the six-year period between the admission of the classes of 1924 and 1930, the decrease in Sheff enrollment caused by changing during Freshman Year only resulted in a net decline of 6%, or 15 men, while the number indicating a scientific training as their original choice, fell off 65%.

Although this naturally necessitates a shift in emphasis, in reality, our course lies in the same direction. The same influences which we believed were turning men from Sheff to the College, could, if counterweighted, be employed to attract to Yale an ever-increasing number of men seeking the best possible scientific training. Admitting a decreasing desire for scientific training, there still are, as Mr. Crawford pointed out, still enough men in this country seeking a high-grade scientific education to fill the halls of Sheff many times. "Qualitative leadership will bring quantitative growth." In that statement Mr. Crawford has struck a keynote! And the steady decline in the number of men dropping out because of scholastic deficiency is the most optimistic sign on the horizon. We are making progress towards our goal of qualitative leadership.

In conclusion, let us once more congratulate the Bureau of Personnel Research for its intensive study of the records which we possessed, but failed to make use of until this time. Remembering that the Bureau was not organized until May and June of this year, such a valuable contribution at so early a date is nothing short of remarkable. Mr. Albert Beecher Crawford, 1911, who has developed the Bureau of Appointments to its present high position of efficiency and service, is responsible for this new accomplishment.

* * *

SINCE the last issue the Association's drive for additional members has proceeded and we are enjoying a healthy increase in enrollment. Not only are we increasing numerically but also in prestige, judging by some of the new titles in our address files.

The present membership of the Association is nearly 1,500, an increase of about 400 in the last ten months. While this is very much to the credit of our Membership Committee, it is still a fact that 1,500 out of some 7,000 Sheff graduates leaves something to be desired.

The Membership Committee has organized its work along lines similar to the endowment fund drive, with agents and sub-agents in each class so that all Sheff graduates have been personally canvassed on behalf of the Association through one means or another within the past few months. We believe that it is a lack of understanding of the need that the Association is filling, rather than a lack of interest in Yale affairs that is responsible for a not larger percentage of graduates becoming members.

Elsewhere in this issue you will read the results of the investigation by the Bureau of Personnel Research into the underlying reasons for the relative distribution of three typical Freshmen classes as between Sheff and Academic. It is our desire that these conditions shall be better understood by Sheff graduates along with the fact that it is our Association's policy to improve Sheff in every way.

It is the wish of the President of the Association that all of its members shall consider themselves on the Membership Committee for the purpose of bringing these matters to the attention of those Yale graduates who are not within our ranks. In so doing it should be borne in mind that Academic graduates are worthy and necessary candidates for membership in the Association. Every far-seeing Academic man knows that if Yale is to continue in the vanguard of American universities, it must have a strong engineering and science department, which is logically the Sheffield Scientific School. Accordingly, it is to the interest of Academic and Sheff men alike to promote the welfare of the Sheffield Scientific School and to take cognizance of the over-population of Academic and the under-population of Sheff.

The Yale Engineering Association is the greatest single force now working for the improvement of these conditions, and our membership campaign is for the purpose of giving more weight to our opinions and recommendations. It should be supported and encouraged.

YOUR ASSOCIATION IS GROWING RAPIDLY!

At the time this issue goes to press the Yale Engineering Association has 1485 members, which is an increase of 209 since last May, when the first issue of this magazine was sent you.

Study Made of Sheff Enrollment Problem

Bureau of Personnel Research Finds Indication of Greater Influence for Decline Apparently Occurring Before than During the Common Freshman Year

CONTRARY to the generally accepted belief among Yale men that the declining percentage of Sheff election among Yale Freshmen during the past six years was due to influences brought to bear upon them by the introduction of the Common Freshman Year, it is shown quite conclusively by figures presented herewith, that the present condition is, on the contrary, due to influences exerted prior to matriculation. This interesting discovery came as the result of a searching and comprehensive analysis of the distribution of the classes of 1924, 1927 and 1930 in regard to the choice of upper schools conducted by Mr. Albert Beecher Crawford, 1911, Director of the Department of Personnel Study. The investigation was made at the request of the Yale Engineering Association, the Dean of Freshmen, and the Chairman of the Board of Admissions and compares the choice of degrees specifically expressed on College Entrance Board blanks, prior to matriculation, with the choice actually made by the same individuals in the Spring of Freshman Year. Each man's preliminary choice was first obtained from his entrance blank. Then his subsequent choice in Freshman Year was ascertained, as well as his scholastic average. His later record was followed through to discover whether or not he graduated with his original class.

It was discovered that there has been a great proportionate decrease in the number of men originally intending to enter the Sheffield Scientific School. Yet it was found that, although the Sheffield Scientific School enrollment has not increased numerically in the same ratio as has the Freshman Year enrollment, the school is today securing a higher grade of students than it did six years ago, with a much better chance of survival.

The following is a summary indicating the tendency of choices both as made before entrance to college and during the Freshman Year, for the period covered by the tabulation. The results are expressed in numerical totals as well as in percentages of the entire respective classes.

ANALYSIS OF FRESHMAN CLASS DISTRIBUTION.

Class.	*1924*	*1927*	*1930*
Total No. in Class	684	844	877
Preliminary intention at entrance to College	258	266	333
	38%	32%	38%
Preliminary intention at entrance to Sheff	227	180	162
	33%	21%	18%
Undecided at entrance	199	402	379
	29%	48%	43%
Undecided at entrance to College	102	243	255
	15%	29%	29%
Undecided at entrance to Sheff	54	117	95
	8%	14%	12%
Undecided at entrance, leaving before choice	43	42	29
	6%	5%	3%
Changes from preliminary intention:			
College to Sheff	23	17	23
Per cent of original choice	9%	9%	7%
Sheff to College	32	35	47
Per cent of original choice	14%	20%	29%
Net total entering College (after allowing for changes)	310	480	554
	45%	57%	63%
Net total entering Sheff (after allowing for changes)	206	238	215
	30%	28%	25%
Total leaving first year	165	126	106
	24%	15%	12%

Sheff Preference Falls Off.

"Two tendencies in these figures are particularly striking," says the report of the Bureau of Personnel study. "First, the increase in the 'undecided' group, and second, the surprising decrease in the percentage originally expecting to enter the Sheffield Scientific School. Both of those factors contribute to the net decrease in the total of students actually going on as Sophomores into the Sheffield Scientific School, but the latter factor, the falling off in the original Sheff group, is the one affecting most strongly the ultimate results. It is evident, from a consideration of the facts above, that the 'undecided' group has divided between the College and Sheff in nearly the same ratio during the six-year period studied, although the College has made some gain over Sheff in this division. Actual changes of choice of school compared with the original choices have remained about stationary for the College to Sheff group but have doubled for Sheff to College.

"The surprising tendency noted is the great proportionate decrease in the group originally expecting to enter the Sheffield Scientific School. During a period in which the size of the Freshman class has increased by nearly two hundred, this group has actually decreased by sixty-five. In fact, this group, in the class of 1930, represented not much more than half as large a proportion of the total class as it did six years earlier.

"The class of 1924 was fairly well divided between the two schools so far as original intention was expressed, 38% of that class expecting before entrance to go to the College, and 33% to Sheff. The original College proportion has remained constant, but the Sheff proportion has fallen to only 18% in the class of 1930. This is a much larger shrinkage than has taken place in the actual percentage of men going on to Sheff, which has decreased only 5%. In 1924, 33% of the incoming Freshmen expected to go to Sheff, and of all those completing the first year 30% actually did so. In 1927, of those entering, 21% expected to go to Sheff, but 27% of those going on as Sophomores actually did enter that School. In the last Freshman class, only 18% were apparently headed for Sheff, which obtained, in fact, 25% of the Sophomores.

"Therefore it is evident that the proportionate decreased in the Sheff Sophomore class, during the last six years, is much less than the decrease in the percentage initially expecting to attend that School. In fact, if the division of Yale Freshmen between the two upper Schools had been determined solely by the intentions expressed before matriculation by entering students, the Sheffield Scientific School would apparently have suffered a greater proportionate shrinkage than it actually has.

Lower Mortality Among Sheff Men.

"One reason why the Sheff Sophomore classes, despite the shrinkage in the original entering Sheff component, have not fallen off more rapidly, appears to be the much lower mortality for the Sheff group in Freshman year. Analysis of the number of men dropped for scholarship, or leaving in the Freshman year, for other reasons, is appended. The actual number of cases is given, and the proportion which that number bears to the total group of which it is a part."

FRESHMAN YEAR MORTALITIES IN CLASSES OF 1924, 1927, 1930.

	1924.		*1927.*		*1930.*	
	Total leaving first year.	*No. dropped.*	*Total No. leaving.*	*No. dropped.*	*Total No. leaving.*	*No. dropped.*
Original College Group	45	43	30	24	43	40
	18%	17%	12%	9%	13%	12%
Original Sheff Group	55	44	10	9	12	12
	24%	19%	6%	5%	8%	8%
Undecided to College	122	81	17	10	17	14
	10%	8%	7%	4%	7%	6%
Undecided to Sheff	10	6	6	6	5	5
	19%	11%	5%	5%	5%	5%
Total undecided group including those leaving before choice	65	46	65	48	51	39
	33%	23%	16%	12%	14%	12%
Coll. to Sheff.	1	1	0	0	1	1
	4%	4%			4%	4%
Sheff to Coll.	2	2	1	1	1	1
	6%	6%	2%	2%	2%	2%
Undecided leaving before choice	43	32	42	33	29	20
Net total	59	52	47	34	61	55
College loss	15%	13%	9%	7%	10%	9%
Net total	66	51	16	15	18	18
Sheff loss	23%	19%	5%	5%	7%	7%
Total for entire class	165	133	126	101	106	91
	24%	20%	15%	12%	12%	11%

"It will be noted that the Freshman Year mortality, for both College and Sheff groups, has decreased during the last six years," continues the report. "Those facts are the more remarkable since the investigators found that the Freshman Year standards, in this respect, are much higher now than they were six years ago. Many men from 1924 actually went on to the Sophomore class with surprisingly low averages (sometimes lower than 60) and were subsequently dropped as Sophomores. Those were not included in the table above, since they could not be properly classed as Freshman Year mortalities. Such cases have greatly decreased in number. As it is, the total Freshman Year mortalities have been cut in half, despite the application of distinctly higher scholastic standards for Sophomore rating. The Sheff group has shown the most striking improvement in this respect, its mortality, during the six-year period studied, dropping from 23% to 7%; while the loss in prospective College students has fallen from 15% to 10%. In fact, forty-eight fewer Freshmen were lost to Sheff from the class of 1930 than from the class of 1924. This saving, which apparently reflects better methods of selection for entrance, has partially offset the declining percentage of entering students originally expecting to attend the Sheffield Scientific School.

"Figures not included in the summary show, as is to be expected, that most of the students changing from an original Sheff intention to the College, enter the latter school as Ph.B. candidates. Figures on elections from the 'undecided' group indicate an increasing preference for the B.A. as compared with the Ph.B. degree in the College. Scholastic averages show that, in general, the 'undecided' group is less successful in curricular achievement than the original College or Sheffield Scientific School groups. This corroborates evidence previously obtained in warranting the assumption that the individual with a clear-cut purpose is likely to do better scholastic work all along the line.

Increasing Percentage Graduate.

"Whatever may be the causes underlying the declining percentage of men originally intending to enter Sheff, the analysis shows that those who now enter it are distinctly better students, and have a better chance of survival with their class, than did the corresponding groups, in previous years. In fact, inspection again of the mortality figures, and of the percentage of entering Freshmen who graduated with their own class, shows that only 58% of the total Sheff group in '24 graduated with that class; while this ratio in '27 had risen for the Sheff group, to 70%. The corresponding College figures are 68% in '24 and 78% in '27. This proportionately greater improvement of the Sheff group seems, from last year's Freshman mortality figures, to be continuing. In fact, the '30 Freshmen who will graduate with their class from Sheff will probably represent a higher proportion of that entire original class, than did the corresponding percentage of '24's men.

"Two conclusions follow from these figures:

"(1) The declining percentage of Sheff elections among Yale Freshmen, during the past six years, appears due to influences, exerted prior to matriculation.

"(2) The Sheffield Scientific School, although it has not increased numerically in the same ratio as has the Freshman Year enrollment, is today securing students of higher scholastic ability, and with a much better chance of survival, than it did six years ago."

After tabulation, the totals were carefully checked with the catalogues of the respective years in order to insure accuracy. There are, however, slight differences between the totals used in the tabulation and those in the catalogues, because of the intentional elimination of a few cases in each class. Such cases fall in two categories: Men who were temporarily rated with a lower class but regained standing with their original group; and men who left college so soon after entrance that they cannot fairly be counted as members of their class, but the number of such cases is so small as to have no significance.

This tabulation differs somewhat from that made for 1930 by the Board of Admissions last year, because actually expressed choices on the entrance blanks were the criteria for this analysis, whereas certain supplementary information in correspondence folders was used for last year's count, thus reducing the proportion of "undecided" cases. The corresponding ratios as between the two schools are, however, unaffected by this difference in method, and the one used in the present count is entirely consistent with itself for the years studied. The final distributions in this tabulation are based on present Sophomore registration, whereas those used in the Board of Admissions' count last Spring were those expressed in May.

Sheff Badly in Need of New Buildings

Is Lagging Behind Many Other Engineering Schools—New Administration Building and More Dormitories Should be Planned at Once

IN an open letter to the alumni of Lehigh University, President Charles Russ Richards declared that, of the many factors affecting and determining the relative standing of a university, the extent and character of its physical plant is not the least. He was asking Lehigh graduates to give their university a new building to house the Electrical and Mechanical Engineering Hall. So convincing was his message that Mr. James W. Packard, of motor car fame, one of Lehigh's distinguished graduates, gave the $1,000,000 necessary for the structure, and work is about to begin on what will be the most modern and complete laboratory of its kind.

This is but typical of the broad physical expansion taking place among our leading scientific universities. After a lagging during the war years our scientific educators have come to appreciate the need for modern laboratories and dormitory accommodation and have pursued as active a course of expansion of physical properties as available funds would permit. They have faced their needs squarely and have not compromised in their efforts to fulfill them. Sometimes the expansion has been necessitated but always it has been prompted by a universal desire to increase the efficiency of the teaching and improve the facilities for research.

"The Gateway to Sheff."

The important part played by equipment in a modern university is convincingly presented by President Richards of Lehigh: "In this respect the requirements of modern scientific and technical education are particularly exacting. To be effective, the work of the classroom must be supplemented by work in a laboratory. It is not alone sufficient to study about a thing; it is necessary to work with the thing that is being studied. The abstract consideration of Nature's laws makes little impression upon a student's mind until he has had personal experience with them. Extensive and well appointed laboratories are, therefore, essential in modern education. The mere inspection of commercial apparatus or even tests of such apparatus under normal operating conditions cannot take the place of well conceived and fully controlled laboratory experiments that are designed to illustrate the physical laws involved. Furthermore, while it is true that the success of any scheme of education is dependent upon the master teacher and that the most elaborate physical plant is valueless unless it is directed by competent men, it is equally true that the work of the great teacher is ineffective unless he has the physical equipment essential for his work. The ablest professors of science and technology are not attracted to those institutions which cannot offer adequate facilities for instruction and research, for such men are concerned equally with the acquisition and dissemination of knowledge."

At Princeton we find an active building program in progress in the Scientific department, including a chemical laboratory which it is estimated will cost $2,000,000 including its equipment, and an engineering building which has necessitated an outlay of approximately $600,000, including $100,000 for its equipment. The chemical building will have a volume of almost two and a half million cubic feet. Incidentally, Princeton has raised within the past year about $1,400,000 for the endowment of seven research professorships, one in mathematics, another in mathematical physics, two in physics, one in biology, one in chemistry, and one in astronomy.

Four and a half years ago Princeton opened its psychological laboratory, which is, we understand, the only separate building in this country devoted to psychology. Substantial dormitory facilities have been added in the past decade.

Rensselaer Polytechnic Institute, which has grown steadily in recent years from an enrollment of 314 in 1903 to one of 1,450 for the present college year, has been one of the leaders in providing buildings and equipment to meet the requirements of present-day scientific education. In 1923 the size of the Russell Sage Laboratory of Mechanical and Electrical Engineering was doubled by an addition costing over $500,000. In 1919, the Walker chemistry laboratory was supplemented with an addition costing a quarter of a million dollars.

In 1925 the Civil Engineering Building was completed at a cost of $325,000. We are advised that the entire student body is comfortably housed in thirteen dormitories, the first being built in 1916 and the last (the Caldwell dormitory) being completed this year.

We could go on, from one institution to another, listing the wealth of additions to the buildings and equipment of each, but it is unnecessary. It is true that the personal element in teaching is far more important than buildings or equipment, but it is safe to apply here the observation that "an army travels on its stomach."

New Packard Engineering Laboratory at Lehigh University which will cost $1,000,000.

Yale should by no means apologize for the equipment of her Scientific School, which was recently supplemented by the new Sterling Chemistry Laboratory. Yet it is significant that, with the exception of this laboratory, which cannot be fairly called

a Sheff building, Sheff has not had a new structure since the Dunham Laboratory of Electrical Engineering was built in 1912. Sheffield Hall, which houses the administrative offices of the School, was built in 1859. The Vanderbilt dormitories, built in 1903 and 1906, house approximately one-half of the members of the school not living in Sheff clubs.

We believe the Sheffield Scientific School is, or should be, on the verge of an extensive building program. We should not be surprised to see, in a few years, unsightly Sheffield Hall replaced by an impressive administration building facing College Street and housing the school's undergraduate activities. We further expect that the completion of the Sheff quadrangle will solve the housing problems. We have hopes that new structures will some day replace the row of 'block houses" along Prospect Street. We believe that the Sheffield Scientific School, once outstanding for the excellence of its physical plant, will again step into the foreground.

Civil Engineering Building at Rensselaer Polytechnic Institute completed in 1925.

THE FERRY MEMORIAL TABLET

Yale Engineering Association Honors Memory of the Designer of the Yale Bowl

A TABLET, which is shown in the frontispiece of this issue, has been placed on the Yale Bowl in memory of Charles Addison Ferry, the designer, by the Yale Engineering Association. The presentation of the tablet was made on June 20, 1927, by Smith F. Ferguson, president of the association.

Mr. Ferguson's address was as follows:

Ladies and Gentlemen:

Charles Addison Ferry was born in the little town of Granby, Connecticut, on January 8, 1852. In 1871 he was graduated from the Sheffield Scientific School of Yale University with the degree of Bachelor of Philosophy. Just twenty years later he received from Yale the degree of Civil Engineer in recognition of his ability in that branch of engineering.

Soon after graduation he began his professional career in the office of the City Engineer of New Haven. There he had a wide and varied experience, which to a large extent laid the foundation for his broad engineering knowledge. All tasks assigned to him were performed faithfully and with skill. In 1892 and for a number of years thereafter Mr. Ferry served as Principal Assistant Engineer in the office of Mr. A. B. Hill, Consulting Engineer. In that position he had charge of many large and important undertakings, one of which was the construction of the water filtration plant for the New Haven Water Company.

Shortly after he opened his own office to practice his profession he was engaged to design and supervise the construction of this beautiful great structure, the Yale Bowl, which rises here above us. Mr. Ferry read a paper describing the Yale Bowl before the Connecticut Society of Civil Engineers, of which organization he was at one time president. At the very beginning of this article he said:

"Because it is something new under the sun or the application of an old idea to a new purpose, rather than for any remarkable engineering feature which it possesses, is the writer's excuse of presenting this paper on the Yale Bowl."

This statement was indicative of his modesty, an attribute which endeared him to all who had the honor and pleasure of knowing and associating with him. This Bowl was his conception. The idea of building a coliseum by digging a great hole in the ground and using excavated earth on a bank for seats carries with it to the lay mind strength and safety. Many with engineering knowledge, however, contended it was not practical to pack the made embankment solid enough so that it could be faced with concrete without resulting in serious cracking. He, however, fortunately was successful in persuading the building committee that it could be done, and his judgment has been vindicated.

No detail was too small for him to overlook. Even the seats are a result of his careful study, combining as they do economy of space and minimum of cost with comfort.

Many of us who have been compelled to sit on the cold concrete of some of the other great stands appreciate his wisdom in providing wooden seats.

Not only did he cause to be constructed a structure so solid that it should stand for ages, but above all his great sense of artistic proportion has made this structure a thing of great beauty,—beauty combined with simplicity and utility—a very rare combination of engineering skill.

The Yale Engineering Association, an organization composed of nearly 2,000 alumni, has erected this tablet with the hope that the memory of Charles Addison Ferry,—engineer, good citizen, loved by all who knew him—will last for many years to come. It is also our hope that the example of his life will be an inspiration to the undergraduates of future generations.

On behalf of the Yale Engineering Association, it is now my great privilege to present this tablet to the fellows of Yale University.

The tablet was accepted by Professor George H. Nettleton, Chairman of the Board of Control of the Yale Athletic Association, as follows:

"At the request of President Angell, and on behalf of Yale University and of the Yale Athletic Association, I am privileged to accept with gratitude this tablet to the enduring memory of Charles Addison Ferry. It is fitly set at the portal that points to the fulfilment of a great design. It answers, while it recalls, the challenge of the poet's searching questions:

"'What hand and brain went ever paired?
What heart alike conceived and dared?
What act proved all its thought had been?'

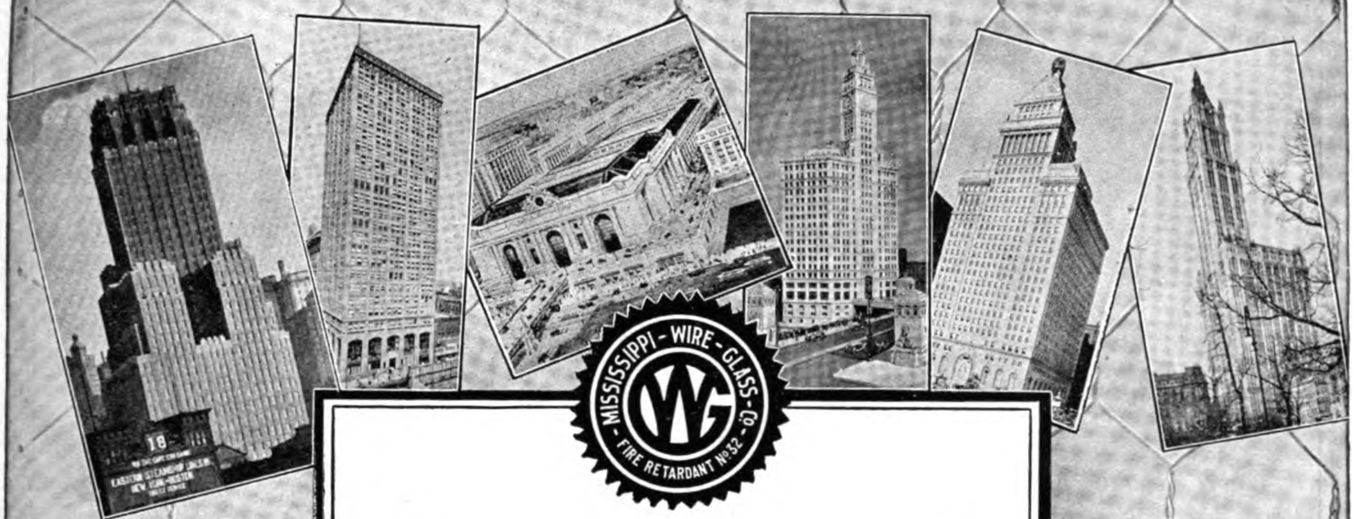
"For Charles Ferry conceived and wrought daringly, watching vision with results not visionary. This tablet, in little—this Yale Bowl, in the large—shall be unto us for a sign and memorial of lasting honor to the name and to the achievement of Charles Addison Ferry."

PERSONALS

Smith F. Ferguson, President of the Yale Engineering Association, was elected president of the Clock Manufacturers Association of America last June, an organization which includes all the clock manufacturers in the country.

* * *

Among the men coming from distant corners to the meeting of the Executive Committee of the Yale Engineering Association, held at the Yale Club on November 11, were: Harry S. Pickens, of Cleveland, O.; Francis T. Pratt, from the General Electric plant at Schenectady; James T. Lyman, from Chicago; Prof. Bradley Stoughton, from Lehigh University; and E. M. Herr, from West Pittsburgh.


MISSISSIPPI WIRE GLASS CO.
MWG
FIRE RETARDANT No 52

METAL STRUCTURE REVEALED BY NEW METHODS

(*Continued from page 32*)

The crystal structure of all of the common metals has been determined by X-Ray investigation during the last few years. This has made it possible to inquire critically into the reasons for plasticity, ductility, change of structure and properties by cold working and annealing, and other unique behavior of metal.

The most malleable and ductile metals, silver, gold, copper, aluminum, lead, iron (at elevated temperatures), nickel, platinum and some others crystallize with a so-called face-centered cubic arrangement of their atoms as illustrated in Figure 5a. As we see them, in the ordinary cast or wrought forms, they are composed of small irregularly shaped grains, each in turn composed of millions of atoms arranged according to the geometrical pattern represented as a single unit or cell in Figure 5a. The neighboring crystalline grains although identical in structural pattern are differently oriented, i.e., the arrangement of their atoms with respect to a horizontal plane would be represented by tilting the unit cell of Figure 5a at various angles to the horizontal.

The plasticity of metals seems to be due to the fact that certain families of planes which may be recognized in geometrical structures developed from the elementary units shown in Figure 5 are thickly populated with atoms which hold one another in position by strong cohesive forces, while from plane to plane the atoms are relatively far apart and weakly coherent. As a result, any properly directed force exerted upon the metal can produce a change in shape, or cause the metal to flow, by the slipping or gliding of one plane over another. The face centered cubic metals possess four distinct families of these gliding planes which are well enough distributed to permit a rather uniform condition of plasticity in all directions and give rise to the high degree of malleability observed in these metals.

Iron at ordinary temperatures, tungsten, molybdenum and a few other metals are known to crystallize in the body centered cubic form represented in Figure 5b. This grouping of atoms does not result in the high order of malleability and ductility observed in the group just described.

The common metal zinc, along with magnesium, cadmium, and certain other less familiar metals, crystallize in the hexagonal arrangement illustrated in Figure 5c. Here, only one family of gliding planes has been positively identified and these are the planes represented by the hexagonal base. Since a thick clab of zinc, which is composed of coarse crystals of various orientations, may be rolled out into thin sheets the metal must possess a high degree of plasticity and this calls for a greater accommodation in the matter of gliding planes than is offered by the single family of basal planes.

There is some evidence that the planes represented by the prismatic sides of Figure 5c may function as gliding planes, but there is another mechanism which may be of service in this situation and is sufficiently characteristic of metal structures in general to merit recognition even in this brief article. This refers to the type of crystal alteration known as twinning, which is illustrated in a general way in Figure 6. While the positions of the atoms are not shown it is not difficult to imagine that the figure represents two separate structures like Figure 5c cut and fitted together so that one structure miters into the other along an inclined plane which contains atoms common to both structures. When stress is applied to a zinc crystal whose basal planes are not in the proper position to permit gliding, the change just described commonly takes place and certain parts of the crystal may then be found in position to favor plasticity by gliding along the reoriented basal planes. There are six possible families of twinning planes in a zinc crystal which makes possible a sixfold redistribution of the gliding planes by twinning. This might be expected to favor a high degree of plasticity quite comparable to that attained in face centered cubic metals by gliding along the four simple families of planes present in the original crystals.

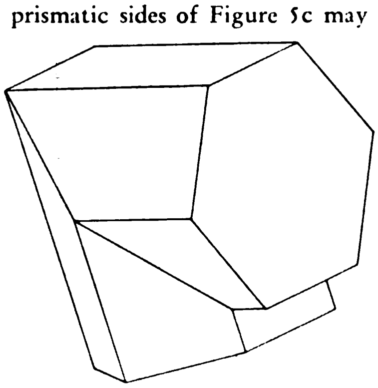
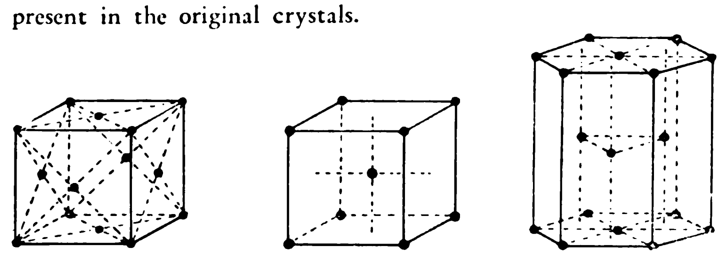


Fig. 6. Model of twinned zinc crystal.



a b c

Fig. 5. (a) face-centered, (b) body-centered, and (c) hexagonal arrangement of atoms in the ultimate unit of crystal structure.

These fundamental conceptions of the crystal structure of metals and alloys are being elaborated and applied to a great variety of theoretical and technological problems both at home and abroad. In these studies the conventional optical methods of metallurgy and crystallography have been reinforced, and to some extent superseded by new X-Ray methods.

In this way it has been determined that the hardness of a metal is essentially resistance to gliding along characteristic crystallographic planes and must be considered in relation to the size of the crystalline grains concerned and the action of alloying elements in modifying the crystal structure of the metal. Rational methods of softening and stiffening metal products are clearly in sight. The conditions at the grain boundaries, ordinarily the seat of great cohesion, and at the boundaries between twinned structures, are being critically studied. The causes of hardening by strain and softening by annealing, which have proven puzzling in the extreme, are every day becoming clearer. Single crystals in many forms are being prepared and tested in compression, tension, torsion, etc., under close scrutiny with a view to applying the results to the more complicated aggregates of many crystalline grains which are found in ordinary metal structures. Inevitably, the general understanding of the ordinary mechanical behavior as well as the chemical and physical properties of metals and alloys will increase by leaps and bounds during the next few years.

RESEARCH IN MINEROLOGICAL LABORATORY

(*Continued from page 26*)

2. Sensitiveness of flame reactions determined. Technique of microflame worked out.

Filter designed, specific for Li, Ca, Rb, Cc, K, Ba, Tl, In.

3. New sublimate collector developed and new technique of applying HI.

4. Adaptation and improvement of Clerici's solution Gr= 4.31.

5. New index liquid technique developed, based on the original idea of Professor Adolph Knopf's microsyringe.

6. New microspectroscopic technique, and new microspectroscope designed, with increased sensitivity and of practical application to minerals.

BERTRAM BORDEN BOLTWOOD

(*Continued from page 25*)

tion up to that time, it offered increased opportunities for the continuation of my scientific work."

In 1909-10 he was granted a leave of absence, and he spent the year with Sir Ernest Rutherford doing research work in the Physical Laboratory of the University of Manchester, where he was the John Harling Fellow in Physics for that year. He returned to Yale in 1910 as Professor of Radiochemistry in the Graduate School, and held this position until his death. In 1913-14 he was acting director of Sloane Physics Laboratory: 1918-19, acting Professor of Chemistry; 1919-22, acting director of Kent Chemical Laboratory. He had much to do with the planning of the Sloane Physics Laboratory, which was finished in 1912, and where he had his laboratory until the Sterling Chemistry Laboratory was built. He had the greater part of the burden in the arrangement and fitting out of the Sterling Chemistry Laboratory. Unquestionably, the strain of the work on the latter had a great deal to do with his breakdown four years ago, forcing him to ask for a leave of absence to regain his health.

Boltwood's researches were largely in the field of radioactivity and practically all of this work is of great importance. The purpose of this sketch is mainly to point out briefly the scientific contributions of Boltwood. His first publications deal with problems in inorganic and in physical chemistry, such as studies on chlorides, molecular conductivities, new devices for the laboratory, and they appeared prior to 1896 and shortly after.

In 1896 radioactivity was discovered by Becquerel, and shortly after that Pierre and Marie Curie made their sensational discoveries in this new branch of science by studying the uranium bearing mineral pitchblende. Boltwood, during the interval of his activity in the private laboratory with J. H. Pratt, a geologist, had, no doubt, much to do with analyses of minerals, and his scientific interest in radioactive minerals became keen and especially so with the announcement of the disintegration theory of radioactive elements by Rutherford and Soddy in 1903, which briefly stated, postulated that an atom of a radioactive element like uranium or radium spontaneously disintegrates emitting energy in the form of alpha rays or beta rays, and that from what is left of the initial atom an atom of a new element is formed which may in turn also disintegrate. This was a bold theory to spring on conservative physicists and chemists of 1903, but today it is no mere theory but an established fact verified in every case. To this verification Boltwood has contributed very materially.

It occurred to others as well as to Boltwood that, since radium and uranium are found in the same mineral, there may be some relation between these two elements. From the Rutherford and Soddy theory one would conclude that one of these elements produced the other. Which was first? Did the second follow directly by the disintegration of the first? We find Boltwood busy on these problems, and a year after the announcement of Rutherford and Soddy's theory, he published in 1904 his first paper in radioactivity, "On the ratio of radium to uranium in some minerals." This was soon followed by papers on "The origin of radium," and "Production of radium from uranium."

By his careful analyses and many times repeated experiments he established the probability of radium being a genetic descendant of uranium, but to prove it required the growth of radium from uranium in the laboratory. Purifying uranium and examining the solution later for radium he found that in 390 days no detectable amount of radium was present! This was a discovery, but of a kind not expected. If uranium or its first product uranium X disintegrates directly into radium there should be plenty to detect in a reasonably short time. Boltwood believed in the disintegration theory, and he saw a possible explanation for the apparently disappointing result, namely, that an element of a long life period may exist between uranium and radium and that a detectable growth of radium from uranium through this intermediate element would require a much longer time than his experiments had permitted. However, if the hypothesis was correct, this particular element should be in the uranium-radium minerals. Now he searches for this "parent of radium." He gives attention to the actinium element discovered by Debierne in uranium minerals. The chemical methods of separating actinium were not very exactly given at that time. but he follows a method in which a precipitate was made with thorium. The substance separated, thought to be actinium, was used to "grow radium." This substance did produce radium, and for a while Boltwood thought that he had proven that actinium was the missing parent of radium. Being a very careful experimenter he repeated every method suggested in literature on the separation of actinium and found that actinium separated with some rare earths without the use of thorium was actually the true actinium and that it did not grow radium. Consequently, his substance separated with the thorium must be something different.

Further careful work showed that his substance was unlike any radioactive element known and that it produced radium in amounts proportional to time; that its alpha particles had a definite range different from the ranges of alpha particles from other radioactive elements. He realized that he had discovered a new element. He proposed to name it Ionium—"a name derived from the word ion." This name is believed to be appropriate because of its ionizing action which it possesses in common with other elements which emit alpha radiation."

Now, another difficulty arose which again was of extremely great importance to be observed. Boltwood separated ionium with thorium. Sometimes he used more thorium than was found good for the purity of ionium (thorium being also a radioactive element). He tried to separate the ionium from the thorium by every known chemical means. He writes, "The separation of ionium from thorium presents indeed a difficult problem and I have been unable to discover any indication that even a partial separation can be effected by the use of such characteristic reactions as . . etc." Here is something. A first-class analytical chemist can't separate two chemical elements after he got them mixed up!

Before stating the importance of this let me call attention to some experiments of Boltwood on thorium salts and thorium bearing minerals. Hahn had discovered radiothorium and found its half value period to be two years. Boltwood's study of the thorium products made him conclude that if radiothorium is produced directly from thorium the half value period should be nearly six years, and he communicated his results to Hahn. Hahn, attempting to reconcile the different values, suggested that an intervening element must exist between thorium and radiothorium and searching for it he discovered it (mesothorium) with half value period of about six years. Boltwood, learning about mesothorium shows that it can be always separated by the same chemical process as a substance called thorium X, i.e., that the two substances must have very similar chemical properties. Here is another fact like that observed with the ionium and thorium. Today we know what the important truth is, namely, that the elements ionium and thorium are *isotopes*, and that mesothorium 1 and thorium X are isotopes, that is, elements occupying the same place in the Periodic Table of Elements, and that the chemical properties of isotopes are iden-

tical and the spectra of isotopes are so nearly identical, theoretically, that the refined methods of today are still incapable of distinguishing between them. Isotopy started with these discoveries to which many others have been added by Soddy and others (Soddy coining the term "isotope") and even the isotopes of ordinary chemical elements are studied (Aston).

Another important discovery made by Boltwood in his analyses of radioactive minerals is the fact that lead is always present in a primary mineral from any one locality (or better, from any one geological period) in a definite proportion to the amount of uranium, and if minerals of different geological ages are analyzed and this ratio is studied, it is found that more lead in proportion to the uranium is found in minerals of older geological formation. This result contains two important facts: first, that lead is a disintegration product of the uranium, and this has since been amply proved; and second, that when a mineral from any geological period is analyzed and the ratio of lead to uranium is obtained (and the atomic weight of the lead from the mineral is also determined), the age in years of that geological period can be calculated. It is the best method we have for determining the "age of the earth" and this method is due to Boltwood.

And yet another important discovery by Boltwood was the constant relative amount of actinium to uranium in uranium minerals and with it the fact that this relative amount is too small to place actinium in the direct genetic line of descent that ionium and radium occupy. Rutherford in his Silliman lectures at Yale in 1906 drew attention to these facts and suggested a genetic branch line. Since then several such "branchings" have been observed in the radioactive series and such branchings are of importance in aiding us to make some deductions about the structure of atoms.

These outstanding contributions of Boltwood may be summarized as follows:

1. Discovery of a chemical element, ionium.
2. Showing genetic relation of uranium, ionium and radium, thus supporting the disintegration theory.
3. Showing that certain chemical elements COULD NOT BE CHEMICALLY SEPARATED, giving the first evidence of "isotopes"; isotopy being a new branch of the physical sciences since this discovery.
4. That lead is the final product of the uranium-radium series.
5. That the ratio of lead to uranium can be used to determine the "age of the earth."
6. That actinium is in a genetic line of descent from uranium but not in the same line as radium.

Besides carrying on these very important studies, Boltwood also studied the helium production (from aplha particles) from radium, polonium and ionium. He gave attention to radioactive waters, being the first in this country to analyze waters for their radon content. During the decade of his greatest activity he published several important contributions each year. He was one of Yale's best known scientific men, and letters from Sir Ernest Rutherford of Cambridge, Mme. P. Curie of the Sorbonne, Professor Stefan Meyer of the Radium Institute of Vienna, Professor Otto Hahn of Berlin, and from others have been received expressing great appreciation of Boltwood's scientific worth and deep sorrow about his departure.

Boltwood was a member of the National Academy of Science; he also was a member of the Am. Phys. Soc., Am. Chem. Soc., Am. Phil. Soc. of Philadelphia, Am. Acad. of Arts and Sci. of Boston, and Connecticut Acad. of Arts and Sci.

ALOIS F. KOVARIK.

POWER REQUIREMENTS OF MOTOR VEHICLES

(Continued from page 12)

other power curve of considerable importance may be called the closed throttle power curve, or the resistance furnished by the engine when used as a brake.

Such a curve is shown by FGH, Figure 2, drawn below the zero line OM, because the power is negative. To get this curve it is necessary to drive the engine at various speeds with the throttle closed, measuring the resistance to rotation.

The braking power of the engine is shown by the line FGH in connection with the down grade dotted lines. For example, on a seven per cent down grade the engine alone will serve as a brake at speed of 40 miles per hour, while at speed of 30 miles per hour the engine will supply over half the resistance, requiring the balance from the car brakes. At speeds above thirty miles per hour the engine becomes quite effective as a brake, requiring no help from the car brakes on moderate grades.

Engine in Second Gear.

The effectiveness of the engine as a brake in slowing up the car is greatly increased by shifting from third to second gear when a steep grade is anticipated. By this change the engine resistance available for braking will be about doubled, or the negative horsepower at 60 m.p.h. will be supplied at speed of 30 m.p.h. in second gear, with corresponding change at other speeds.

A curve JKL has been drawn on Figure 2, showing the closed throttle power curve in second gear. The intersection of this curve with the grade dotted lines shows the effectiveness of the engine as a brake in second gear. Reference may be made to point J, which shows that on an eight per cent grade the engine alone in second gear will hold the speed at 20 miles per hour without aid from the brakes.

Car brakes must be relied on for emergency stops, but the engine is a help even in such cases. The curve FGH, Figure 1, shows that on a six per cent grade the engine in third gear will hold the speed to 35 miles per hour without aid from the car brakes. It follows that if post roads were made with grades not exceeding six per cent, brakes would not be required under touring conditions except in emergency use.

SCIENCE HELPS DEVELOP EMOTIONAL ART

(Continued from page 15)

the proper mixture of red, green, blue, and yellow or amber, almost any color hue or tint can be obtained. To get the three primary colors the light from an ordinary incandescent lamp is passed through media which selectively absorb various colors. Colored gelatin or glass is commonly used.

Ultra-violet Rays Reveal Ghosts.

Ultra-violet light is invisible to the eye, for its wave length is shorter than that of the violet at the end of the visible spectrum. In special cases it may be useful on the stage, as in making an object mysteriously appear and disappear. For example, in a ghost scene the ghost's clothing may be painted with chemicals that emit visible light when ultra-violet light is thrown on them; the ghost will then be visible and invisible as is passes in and out of the ultra-violet rays. Ultra-violet light injures the human eyes so that when it is used care must be taken to shield the eyes with glasses which will not permit the passage of the rays.

MECHANICAL ENGINEERING.

(Continued from page 35)

Prof. E. H. Lockwood is planning to continue his work on air resistance of automobiles, an investigation which was begun last Spring. This work will consist of very accurate determinations of rolling resistance on his well-known chassis dynamometer, as well as numerous coasting tests on Shelburne Mountain. Prof. Lockwood will be assisted in this work by Howard W. Best, recently appointed Instructor in Mechanical Engineering, and Mason F. Smith, Research Assistant in Mechanical Engineering.

Prof. L. C. Lichty is building an optical indicator with a very high natural frequency of vibration. This instrument is to be used in a study of the detonation process occurring in the internal combustion engine cylinder.

MATHEMATICS.

(Continued from page 35)

last year. Professor Miles' course in Advanced Calculus, which has been given for several years, also shows a marked increase in enrollment.

Because of this increased interest among the upper classmen a faculty committee has been appointed to consider the best way of continuing and increasing this interest. A report will be made later in the year.

New Members of the Department.

Professor Oystein Ore of the University of Oslo has been made Assistant Professor of Mathematics, with assignment to the Graduate School.

T. H. Rawles, Ph.D. Yale 1927; Mr. T. C. Benton and Mr. H. T. Engstrom have been appointed Instructors, with assignment to the Freshman Year.

PHYSICS

(Continued from page 35)

absence and is engaged in research work on the conductivity of metals at King's College, under Prof. O. W. Richardson.

Prof. D. A. Kreider of the Physics Department is on leave of absence and is to start soon on a tour around the world.

Dr. L. M. Kirkpatrick, of the California Institute of Technology, who has been appointed Sterling Fellow in Physics, will carry on research work on crystal structure.

New Appointments.

New appointments in the Physics Department include Prof. L. W. McKeehan from the Bell Telephone Laboratories as Director of the Sloane Physics Laboratory; Asst. Prof. E. O. Lawrence, Asst Prof. J. E. Pomeroy, and Asst. Prof. C. L. Swisher. New instructors include J W. Beams, G. W. Gardiner, and Joseph E. Henderson.

FORESTRY

(Continued from page 35)

Association Professor of Lumbering, is making a study of domestic and foreign wood and lumber prices and the factors influencing their trends in connection with their bearing on the results of the practice of forestry in this country.

Mr. George A. Garratt, Assistant Professor of Forest Production, during the past two years has been engaged in a general study of wood preservation, particularly in relation to present and future timber supply. At present he is also preparing a textbook on "Mechanical Properties of Wood."

Mr. H. H. Chapman, Harriman Professor of Forest Management, spent his sabbatical year investigating the taxation of forest property as a member of the U. S. Forest Taxation Inquiry. His personal share in this work covered the forest region of Minnesota.

Prof. R. C. Hawley has been conducting a research in the planting of red and white pine in sample plots from which measurements and descriptions are taken at five-year intervals. The plots are situated on the 2,000 acres of the New Haven Water Company. He is also conducting thinning experiments in pine and hardwood stands in New Haven and in Keene, New Hampshire, as well as revising a textbook on "Practice of Silviculture."

Mr. S. J. Record, Professor of Forest Products, has been engaged in the classification, anatomy, properties, and uses of woods, especially of tropical trees; concerning the last he is editor of the quarterly journal, *Tropical Woods*. Having made explorations in the forests of British Honduras, Guatemala, and Spanish Honduras, he is now studying the woods of Panama in co-operation with the United Fruit Company, after which he expects to go to Liberia in connection with the Firestone Plantations Company.

ELECTRICAL ENGINEERING

(Continued from page 35)

Prof. A. E. Knowlton devoted part of his summer to making an appraisal of the properties and report on certain operating features of the system of the Clinton Electric Light and Power Company, serving Clinton and Madison. He had as assistant Mr. T. A. Abbott, when he was not engaged with the surveying courses at the East Lyme Camp or with the Mechanical Technology course.

Professors Knowlton and Warner have been re-elected Chairman and Secretary respectively of the Connecticut Section of the American Institute of Electrical Engineers. The procedure of one-term tenure was departed from principally because the Connecticut Section is to be host for the Northeastern District Regional meeting in May, 1928, and the sessions will be held at the University. The Regional meetings held in various places in New England or New York during the past five years have drawn attendances of from 350 to 600 of the 4,500 members of the A. I. E. E. in this territory. Prof. Knowlton is also a member of the Institute Meetings and Papers Committee which passes upon all technical papers for publication in the Journal and Transactions and also prepares the program for the three National and several Regional meetings of the year.

Mr. F. T. McNamara again spent the summer in the Research Bureau of the Brooklyn Edison Company.

Mr. W. W. Sherwood has this summer investigated all the telephone lines in Connecticut with regard to exposure to power circuits.

Three classes in Electrical Engineering of the New Haven College are being conducted by members of this Department in the evening in Dunham Laboratory.

Prof. W. B. Hall has been with the Connecticut Company on the installation of the mercury arc rectifiers which are now supplying energy for Bridgeport's street cars, and oscillographic investigation of these rectifiers is now being carried on. The use of mercury arc rectifiers in large cities is new in this country, and the Bridgeport installation is attracting nation-wide attention.

Prof. R. G. Warner was on leave of absence part of last year to participate in hydro-electric power studies in Maine. His talk on tidal power and the Passamaquoddy project at the Tau Beta Pi banquet in May was based on information gathered at that time.

MEDICINE

(Continued from page 34)

This year in addition to work on Mammalian Physiology, the department will work in General Physiology inasmuch as an additional division has been created in the Department of Physiology, namely, Division of General Physiology. Dr. David I. Hitchcock will be Assistant Professor and Dr. R. S. Anderson will act as Instructor.

Department of Anatomy.

Dr. C. M. Goss and Mr. Frank (Sheff) are studying some of the electrical properties of cells by means of Chamber's micro-dissection apparatus.

Dr. L. S. Stone is continuing his studies of transplanted eyes.

Dr. Burr and Mr. Helgesson are making experimental study of pyramidal system in monkeys.

Dr. Harvey and Dr. Burr are continuing their study of the origin of the meninges.

Dr. van Campenhout, Belgian Foundation Fellow, is carrying on an extensive study of the sympathetic nervous system.

NEXT GREAT REVOLUTION BIOLOGICAL

(Continued from page 22)

separated and distributed where they will do less harm. Crime, too, appears to be at an extremely low ebb, and murders are almost unknown.

One of the evidences of the high social level maintained in Stockholm is found in the appearance of the houses. In the residential districts, to be sure, the houses are usually set close to the street and do not have pretty lawns as ours do. Nevertheless, almost all of them are neatly kept and have flower boxes outside the windows. This is so universal that practically all parts of the city give a general effect of comfort and of a love of beauty rarely evident in the poorer parts of most of our great cities. Another striking fact about Stockholm is the large proportion of the laboring classes who have small country places on the beautiful islands in the lakes and bays scattered around Stockholm. Almost nowhere else do so large a portion of the working people move out of the city during the summer.

All this does not mean that Stockholm is wealthy compared with American cities, or that its finest streets can compare with ours. Sweden is an old country; it lies far from the main lines of commerce; it is poorly endowed with natural resources. Thus its average wealth is far less than ours, and almost none of its rich men can boast of such accumulations as are fairly common among us. But if the top of the economic pyramid thus stands at a lower level than in America, any possible loss in this respect (if such there be) is more than compensated by the fact that the lowest levels are also cut off. Thus on the basis of substantial, wholesome comfort, this city where the birth rate is highest among the most competent and well-to-do portions of the community, and lowest among the poor and incompetent stands almost unsurpassed.

How far these conditions are due to the wide practice of birth control it is impossible to say. This much, however, is clear. A study of the actual conditions in America, England and other countries, leads to the conclusion that one of the crying evils of our day is the low birth rate among the upper classes and the high birth rate among the lower classes. Deeper study, however, shows an opposite tendency which manifests itself when people within a single social level are compared. There the highest birth rate is found among the most valuable members of society, while those who are less valuable are dying out. All this suggests that it is imperative that birth control spread widely among the lower classes, but that the upper classes adopt a new ideal and have larger families. Then we turn to the world as a whole and find that in the only city thus far studied where approximately such a condition actually prevails, the status of civilization is extraordinarily high.

PERSONALITIES

(Continued from page 33)

It is at his fireside, however, that the student gains his truest appreciation of Dean Walden's character. Here he lays aside the various worries and harassments of his official life and devotes himself whole-heartedly to the role of host. A student feels at home from the moment he steps inside the door and sees the welcoming smile until he leaves with a hearty "come back to see us soon" ringing in his ears. Never a moment of uneasiness or timidity is allowed. How many recall with distinct pleasure the memories of these meetings in after years.

In the final analysis, we find that Dean Walden combines the attributes of a teacher, a director, and a friend of youth. From each phase of his character he has given his utmost that the youth who come here may be moulded into Yale men.

C. D. M.

THE PHYSIOLOGICAL ASPECT OF ATHLETICS

(*Continued from page 10*)

he continued for 40 minutes. At first his pulse rose to 160 beats and continued there for 12 minutes; at the end of that time he had his second wind according to his feelings and his pulse dropped to 120 beats per minute. During this time his heart was pumping about 19 liters of blood per minute. After 32 minutes of the exertion his pulse rose steadily; at the same time he complained of fatigue. At the end his pulse had reached 240 beats per minute, but his circulation had at the same time fallen to 14 liters.

One of the interesting points in connection with the inefficiency of a rapid pulse in exertion lies in the fact that it is probably the explanation for the effect that smoking, and, to a less extent, coffee and tea, have upon the "wind." These substances are drugs which increase the rate of the pulse but without appreciably increasing the amount of blood pumped. Under exercise the rapid pulse limits the rate of the circulation; consequently the man has "poor wind." The part played by emotion, as in the rapid pulse just prior to a race, does not have the same effect as does the rapid pulse arising from other causes. In these cases the emotion ceases when the race begins and the pulse rate is not abnormally high under the exertion. The relationship between a rapid pulse under exertion and the life led by the men in training is illustrated by the case of a varsity athlete who was allowed to break training for a fortnight because of minor injuries. He improved his opportunities for pleasure so well that the exercise on the bicycle induced a pulse of 200 per minute. He then returned to training and after another fortnight came to the laboratory to be tested. Under the same exercise his pulse was now 140 per minute.

FIREPROOFING WOOD A GROWING INDUSTRY

(*Continued from page 24*)

requirements. Work is being done on this problem now.

A second important factor in limiting the field of the present commercial treatments is the water-solubility of the impregnated chemicals and the comparative ease with which they may be leached out of the wood, a condition which confines the treated material to interior use, where it is protected from the elements. The "fireproofing" of shingles, siding, and other forms of exterior construction offers great possibilities, and a number of attempts are being made to devise a permanent treatment that will be suitable for such products. At least two rather distinct methods are being followed in these endeavors at the present time. In one, the wood is subjected to a second impregnation with some substance, such as a soap solution or an organic adhesive, like isinglass, which reacts with one of the chemicals previously injected into the wood to form an insoluble seal. Such a seal is not necessarily a fire-retardant itself, but serves to prevent the leaching out of the effective soluble salts contained in the wood. The second method is dependent upon the formation of an insoluble fire-retardant chemical within the wood. In this treatment, an anhydrous salt, such as antimony trichloride, is forced into the wood in an oil solution, the oil serving as a carrier and being later recovered. The impregnated salt, upon hydrolysis, forms an insoluble oxide, which is claimed to have decided advantages as a fire-retardant. While none of these reputed permanent treatments are as yet in commercial use, they have all apparently survived the experimental stage and plans are being projected to place "fireproof" shingles, siding, and the like, on the market in the near future.

UNUSUAL FACILITIES AT ENGINEERING CAMP

(*Continued from page 18*)

plete information before the best location can finally be determined. Continuity of the work of location is further maintained by means of a single large roll map to which each class adds the topographic details of its own particular section. Upon this map the extension of the located line is also projected. As only the most careful draftsmen of each class are selected for this part of the work it is considered something of an honor to be allowed to draft on the "big map."

Students Co-operate in Camp Management.

Representatives of the various student groups met occasionally with the camp faculty to discuss matters pertaining to athletics, and to various details of camp welfare, and credit for a most excellent camp spirit is due to the interest and co-operation of these advisors. Through the efforts of the student committee a sufficient sum of money was collected to maintain the athletic equipment, consisting of indoor baseballs, bats, volley ball, footballs and to make such replacement as may be necessary to put the radio outfit in serviceable condition for the next camp to enjoy. A camp store supplied drafting materials, and in addition a canteen was conducted at the barracks. Excellent table board was furnished for the camp throughout the summer, and no second blast of the siren was necessary to summon the men.

Packing up and breaking camp at the close of each course were accomplished without confusion. At prearranged signals the men in each barrack carried their blankets, lanterns and other camping equipment to headquarters for a final inspection before packing them away for another season. In a surprisingly short time all camping equipment was completely stored and the men returned to the drafting room to put a few finishing touches on the maps which were due "as is" when the siren announced the final luncheon and the closing of the 1927 camp.

The next immediate needs of the camp are in athletic space and equipment. It is desirable to have room for tennis and perhaps volley ball. An open space for football would also be a distinct asset. Early completion of a playing field and provision for a float and piers in the lake constitute the most desirable additions to the recreational facilities of the camp. For students with an inclination for reading a camp library supplied with books on biography, history, travel, etc., would be very useful.

The camp is already one of the features of "Sheff" and is regarded as an integral part. The Yale Engineering Association has done a fine and enduring service for engineering at Yale in providing funds to secure such excellent facilities for practical work in the field.

LECTURES ON TELEPHOTO APPARATUS

How it is possible to send pictures over the telephone in seven minutes was described recently at the Mason Laboratory by R. D. Parker, of the Research Department of the American Telephone and Telegraph Company, in an address before the Connecticut Section of the American Institute of Electrical Engineers. Mr. Parker said that while the mechanism for the transmission of photographs over extensive distances has been primarily developed for use on telephone lines, it has been demonstrated experimentally that it can be used to send photographs by radio when atmospheric conditions are such that steadiness of transmission and freedom from interference prevail.

OUR CONTRIBUTORS

Professor Edwin H. Lockwood, who at present is working with the General Motors Corporation on the measurement of air resistance of motor cars travelling at high speeds, graduated from the Sheffield Scientific School in 1888, received his degree of M.E. in 1892, and his Ph.D. in 1901. Since this time he has been connected with the University doing research automobile testing, especially in automobile tires and radiators.

* * *

Professor Howard W. Haggard received his Ph.B. degree from the Sheffield Scientific School in 1914 and his M. D. cum laude from the Yale School of Medicine in 1917. In 1919 he was appointed instructor of applied physiology. While at Yale Dr. Haggard has carried on experiments with poisonous gases in collaboration with Dr. Yandell Henderson, and recently was connected with experiments the data from which were used in the designing of the ventilation system for the new vehicular tunnel in New York.

* * *

Professor Champion H. Mathewson was appointed Professor of Metallurgy and Metalography in the Sheffield Scientific School in 1919. He graduated from the Scientific School in 1902 and was afterwards an instructor in chemistry at the Massachusetts Institute of Technology. He took his doctor's degree abroad and has taught at Yale since 1911.

* * *

Mr. Sidney K. Wolf received his B.S. at Louisiana State University in 1922 and his M.S. at Yale in 1926. He was designing engineer with the Westinghouse Electric Co. for two years and has been an instructor in electrical engineering at Yale since 1924.

* * *

Ellsworth Huntington, who is now Research Associate in Geography at Yale, received his B.A. at Beloit in 1897; his M.A. at Harvard in 1902, and his Ph.D. at Yale in 1909. Professor Huntington besides being interested in Geography is well known as an explorer and anthropologist. He attended the Pan-Pacific Scientific Congress in 1923 as a representative of Yale University.

* * *

George A. Garratt, assistant professor of Forest Products in the Yale School of Forestry, received his B.S. degree from Michigan Agricultural College, and his masters degree in forestry at Yale in 1923. The last two years he has spent at the University of the South in charge of the Department of Forestry.

* * *

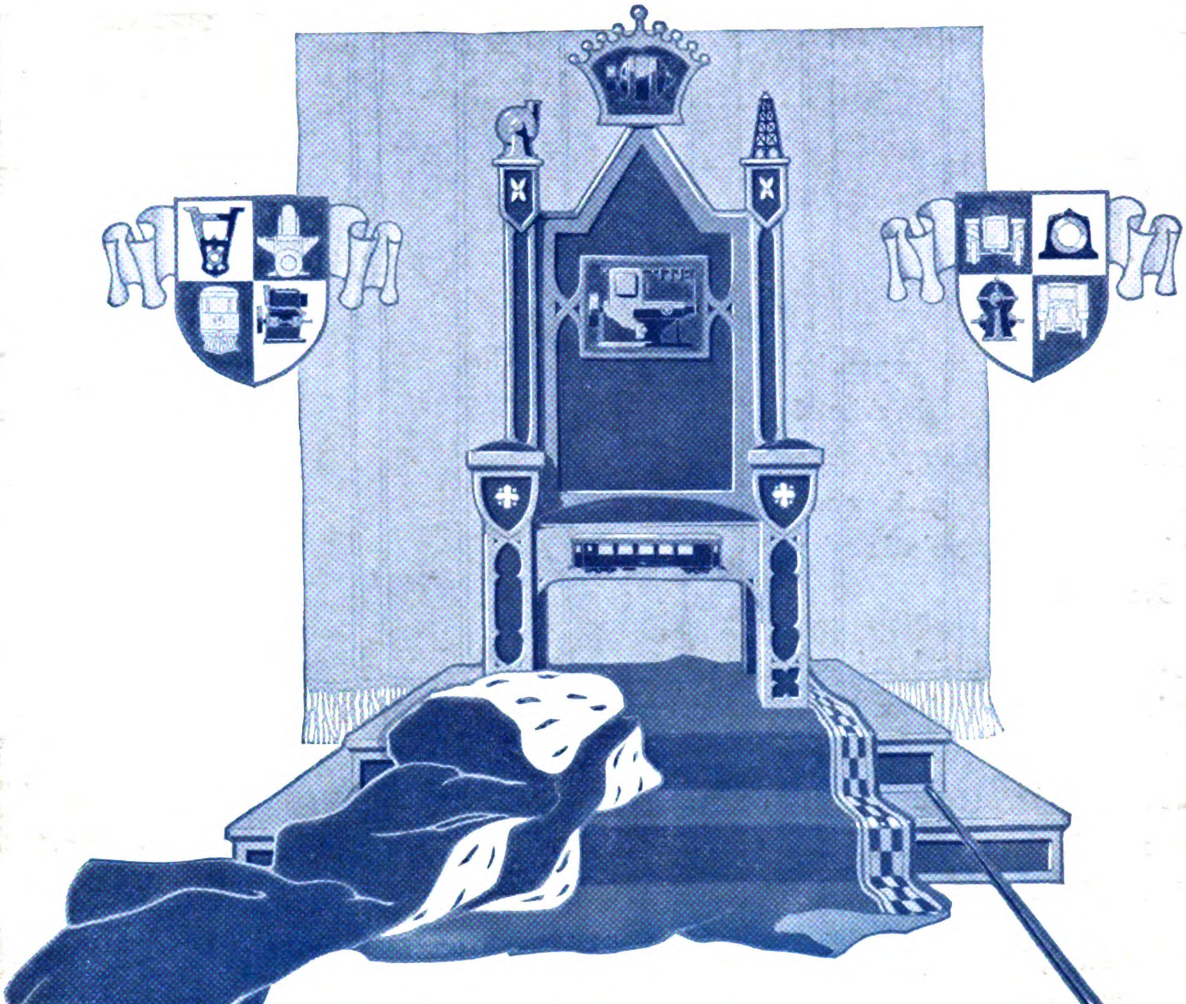
Professor Alois F. Kovarik, who received his degree of Ph.D. in 1909, and his rank of Professor in 1925, is an honorary member of the Society of Czechoslovak Mathematicians and Physicists. He is known for his work in investigating the number of gamma rays emitted by radio-active substances per atom disintegrating.

YALE ENGINEERING ASSOCIATION PERSONALS

Prof. H. L. Seward, '06 S., was employed in Washington, D. C., during the summer on a special board dealing with the re-organization of the Naval Reserve. Later he was Third Assistant Engineer on the S. S. Leviathan.

* * *

R. C. Morse, Jr., '06 S., has been promoted to the position of General Superintendent of the New Jersey Division, Pennsylvania Railroad, with offices in New York.



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THE YALE SCIENTIFIC MAGAZINE

VOL. II JANUARY, 1928 No. 2

Portland Cement Association Building, Chicago, Ill.—is 100% concrete. The structural frame is reinforced concrete, floors are concrete girders and slabs. Monolithic concrete and cinder block are used for curtain and partition walls. The roof is reinforced concrete beam and slab construction. The exterior walls on street frontages are pre-cast concrete. *(See page 7).*

PUBLISHED QUARTERLY IN THE INTERESTS OF SCIENCE AND ENGINEERING IN THE SHEFFIELD SCIENTIFIC SCHOOL

PRICE FORTY CENTS

Pharaoh Wrote Few Letters

POST OFFICE, CAIRO, EGYPT

Now during the tourist season, the mails out of Cairo are tremendously heavy. And no wonder! Everyone who travels in Egypt, who comes into contact with the most ancient of civilizations, must say something about his impressions to someone—even if he has hitherto been a lazy correspondent. He may send only a postal card showing the Great Pyramid with "X showing the spot where I ate my luncheon." But he must write something!

And since the discovery of the tomb of Tutankhamen, tourists have multiplied, impressions have been voluminous, and the mails have increased enormously. "Of course, you can't imagine it without being here, but I simply must tell you about....." And so on.

It is very lucky for the correspondents that with her wonders of antiquity, Egypt did not also inherit the ancient postal system. Only the Pharaohs and the great officers of state could indulge in the luxury of corresponding with a foreign country—and a letter from the King of Egypt to the King of Babylon might take months in transit. Some of these royal letters have come down to us. They are very long, full of elaborate salutations and important news—as if their writers considered their composition the event of a season.

All things considered, we may be grateful that the modern postal system of Egypt is what it is—efficient, orderly, up-to-date. Of course, the Cairo Post Office is equipped with Otis Elevators.

So with the advance of civilization, Otis, the symbol of twentieth century convenience, has been put at the service of the Pharaohs of Egypt in spreading their fame far beyond any worlds which they could even have dreamed of! The pyramid builders would, we feel sure, appreciate the marvel.

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World

To the Daniel Boone in every man!

IT is still the day of the trail blazer. In the telephone industry pioneers are cutting new paths in the knowledge of their art.

This industry is continually on the threshold of new ideas, with each development opening up a vista for its explorers to track down.

Their activity will be as engineers in laboratory research and plant operation, but also in supervisory and executive positions — planning the course of activity for groups of men and carrying the burdens of administration.

The responsibility and opportunity of management take on an increasing importance in an industry such as this, where forward-looking leadership must point the way to ever better public service.

THE YALE SCIENTIFIC MAGAZINE

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The New Engineering

Chas. F. Scott

"*Engineering is the dominant power in the world; others are gradually being pushed aside and you become the dominating factor in civilization*".

In these words Sir Esme Howard, British Ambassador introduced his address on Great Britain in World Politics before American Engineering Council in Washington a few weeks ago.

"*As a lawyer speaking for lawyers we recognize that we have now entered the domain of economics rather than law. As you engineers take that place which we have so long enjoyed you will enter into a broader field than the necessarily narrow and technical one*".

Thus spoke Governor Brewster of Maine to engineering educators a few months ago.

Now these men are not engineers, intoxicated by the magnitude of achievements in their own field; the international statesman and the lawyer-governor are viewing modern life broadly. What is this "engineering" which they find so dominating a factor in the past and of such significant promise for the future? Surely it is not what most people think about when they hear the word.

Light is afforded by Dean Kimball of Cornell, President of American Engineering Council, when he recently pointed out the larger significances of engineering as an underlying factor in the power and machinery and industry and transportation which have increased our per capita wealth tenfold since 1850—tenfold in half the life period of the nation. No wonder our outlook has been changed. Our pioneer grandparents struggled long hours for the necessities of life; our workers today use power and produce abundance in shorter hours, at higher wages and less cost. All of us enjoy everyday conveniences which were impossible even as luxuries a few decades ago. Universal education once economically impossible is now regarded as a right. Commerce, business, finance, organization, management, economics, government, international relations have undergone profound changes and the end is not yet—and an underlying essential factor in these changes is the work of the engineer.

Other aspects of the new engineering were presented by Harold W. Buck, '94S in broadcasting "Some Points on the Engineering Profession" from Dunham Laboratory a few weeks ago.

"*The scientific, technical and industrial forces created by the engineer have swept over the world, killing both time and space. Old methods and old customs have been wiped out. The development and distribution of power has increased man's productive capacity a thousand times. A new world has arisen. The old point of view has gone.*

"*Herein lies the real responsibility and destiny of the engineering profession. The conception of what engineering is should be broadened. These new problems which confront the world are largely the result of the engineer's work and it is logical and proper that he should assist in the solution of them. A humanistic element has entered engineering.*

"*There is a common feeling among engineers that matters of business, finance, politics, etc., in some way belong to other men. As a matter of fact there is no better or more logical field for an engineering career than business, commerce, finance or politics.*

"*It is in just these branches of human activity where the knowledge and training of the engineer are sorely needed. What we need is more engineering leadership in its broadest sense in all fields of work with the clean cut, logical and accurate methods applied which are a part of the religion of the true engineer.*

"*Practically every business today is based upon science and engineering and the greatest demand in corporate organizations at present is for men of engineering training with executive ability, business sense and breadth of view.*

"*Let the engineering student learn all that he can of science, mathematics and mechanics both theoretical and practical, but after graduation, I believe that it would be best for all if only those of special ability and genius follow along such theoretical activities as research and design. The world does not need more new kinds of machinery nearly as much as it needs men competent to direct broadly and intelligently what we already have*".

This is a scientific age. The engineer applies science; he makes its discoveries fruitful. Electricity is his great tool for using energy, for transmitting and applying it to a thousand uses, largely through vast systems for power and communication. Modern electric service results from the combined efforts of electrical, mechanical, civil and chemical engineers and of industrial, commercial and financial agencies all contributing in new ways to human service, bringing the comforts and luxuries of a higher standard of living with leisure for developing the refinements and spiritual values of life. All this is to us an everyday commonplace affair.

In larger, discriminating vision President Angell used these words in his broadcasting at the same time from the Students' Electrical Exhibition:

"*The story of electricity in modern life is a romance unequalled in history*".

Are not Ambassador, Governor, Educator, Engineer and President in agreement as to the foundation of science and engineering in modern civilization?

Concrete—Its Successes and Failures

Sound Engineering Practice Essential to Successful Construction—Failures can be Traced to Use of Haphazard Methods

By Prof. Theodore Crane

FOR over two thousand years concrete has been used as a material of construction. At the present time there is probably no medium so universally employed in important structures, with the possible exception of structural steel, and yet, on every hand, we see evidences of the partial failure of concrete work. What is the reason for this condition? Is it due to some inherent fault in the material? I think not; there are too many examples of excellent work, both in this country and abroad, to warrant any such conclusion.

The chief reason probably lies in the fact that the making of concrete is a manufacturing process carried on upon the job and a process apparently so simple that every tyro considers himself competent to employ it. As concrete can be made by anyone possessing the necessary materials and a square-edged shovel or a small gasoline-driven mixer, it is not unusual for the so-called contractor to undertake the building of a wall, or sidewalk, or even a self-supporting floor upon his own responsibility. The outcome is sometimes successful, but often more or less trouble results. When owner or architect are again on the point of choosing a structural material such "horrible failures" of concrete are brought vividly to their attention through the thoughtful activities of commercial engineers representing other building materials. Sometimes they even quote scientific publications of surprising content which would cause the casual reader to doubt the sanity of one experimenting in the use of such a hazardous type of construction. Of course we must have a little burlesque even in the building industry, but are we so prone to condemn other materials because of inappropriate use, or faulty construction? Do we criticise brick because it is almost impossible to make an eight-inch exterior wall tight against wind-driven rain? It seems hardly fair to condemn one of the oldest, most permanent, and universally applicable of all materials on the ground that the apparent simplicity of its manufacture results in its use by incompetent workmen.

Factory of E. R. Squibb & Sons. An interesting example of industrial work executed in reinforced concrete. Turner Construction Company, Builders. Russell G. Cory, Architect.

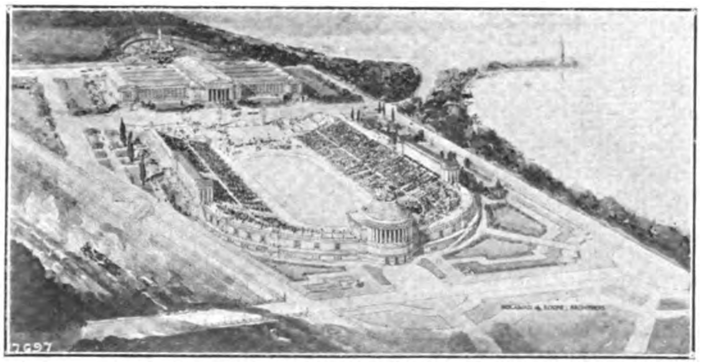
Inefficient Men, Not Materials, Cause Failures.

In the final analysis it would appear that the fault lies with those who employ inexperienced individuals to design and construct the work. Such individuals and organizations usually serve for less money than those who know their business. In the field of concrete construction false economy has reaped an appalling harvest. There are isolated cases where jobs have been "skinned," but at the present time I am inclined to think that such are exceptional. Most trouble in this field is directly traceable to a lack of knowledge of the principles of design and construction. Concrete is not an easy material to use. The stresses in concrete frames are too highly indeterminate to be easily computed by inexperienced engineers. A vast amount of work is built from designs furnished without charge as a bonus for the use of some proprietary scheme, or system of design. To be sure, many patented types of construction are controlled by firms employing designers of the highest ability, but the principle of considering engineering service, particularly in reinforced concrete work, as merely a minor detail, something to accompany a bill of materials, is not sound economics. Design is far too important a matter to be handled in such a casual manner.

Error in design, however, is seldom responsible for failure, or impairment of the utility, or appearance of reinforced-concrete structures. Such faults are usually concerned with economy. In as simple a matter as the selection of a floor system, suitable for either a structural steel or reinforced-concrete skeleton, it requires not only an entirely unbiased viewpoint, but a fairly exhaustive knowledge of the subject to make a choice particularly suited to the conditions of span, load and architectural plan. Again, in the design of buildings, the old principle of the one-horse chaise is too often violated. One link in the chain will be of less strength than the other links. There is certainly no justification for designing a series of reinforced-concrete continuous beams with critical sections over each support twenty-five or fifty

per cent weaker than the remaining portions of the members and yet this condition is all too common in certain types of work.

Many of our antiquated building codes contribute their quota of inconsistencies which complicate the problems of the designer. For example, certain proprietary types of floor construction, which have been approved for use in some of our largest cities, employ moment coefficients one-third less than those required for exactly parallel designs not covered by patent rights. This condition is due to the initiative of the patentee, who has gained the approval of his system by actual loading tests. In many cases the data thus obtained amply justify the closer design for all similar systems, but can be applied only to the particular system that underwent the test.



Architect's Study for the Grant Park Stadium, Chicago, Ill. Holabird and Roche, Architects.

In the design of certain types of reinforced-concrete columns the unit stresses per square inch of cross section vary approximately fifty per cent under different building codes for exactly the same combination of steel and concrete. A short time ago, it was necessary to redesign the columns of a concrete building, to be erected in a small city of New England, for the reason that the designer, a New York City engineer, had followed the New York City code, which, for this particular type of work, permitted the gross cross-section of the column to be considered as bearing. The local code required that the two outside inches of concrete be regarded as only fire-proofing; in comparatively small columns this made a considerable difference. Another example of the complexity of concrete design, as applied to buildings, is in relation to the so-called "girderless" floor construction. For this type of work every city has its own code. From coast to coast, from Maine to Florida, with the exception of those which have adopted the recommendations of certain engineering committees, they all have different rulings.

Such is the present situation facing the designer in concrete. It is surprising that actual failures sc seldom result from errors of design, but it is regrettable that economy is so often frustrated by a lack of appreciation of the difficulties on the part of those not specializing in this material and by the inept regulations under which the work must be carried out.

Properly Graded Aggregate Essential.

By far the greatest difficulty, however, occurs in the field and might be entirely prevented by proper specification and supervision. First comes the matter of materials. Although it is an invariable rule among good constructors to require the testing of cement and its conformity with the requirements of the American Society for Testing Materials, it is very seldom that the cement will be found at fault. The aggregate, however, particularly the sand, or fine aggregate, should receive the closest attention. Again, we have the standards of the American Society for Testing Materials and of the American Concrete Institute, the observance of which are guarantees of quality. Most trouble with materials has been caused by foreign matter in the sand such as results from vegetable decomposition. That can easily be detected by the colorimetric test. Occassionally, trouble has been due to the use of an inferior kind of coarse aggregate but it is very exceptional when one passing the requirements of the Institute will need further investigation. Any potable water is suitable for concrete work and, in fact, only a high degree of pollution from sewage or manufacturing wastes causes reduced strength.

Given good materials the next prolific source of trouble is in their proportionment. Here the blame usually lies upon the engineer or architect who believes that one part of cement, two parts of sand and four parts of crushed stone, or gravel, will make a dense concrete testing two thousand pounds per square inch in ultimate compression strength at an age of twenty-eight days irrespective of the grading and resulting void content of the combined aggregate. If the specification writer had spent more time on the cracker barrel in the country store of his home town he would probably remember that the "most potato" will not be found in the barrel filled with all big ones, or all small ones, but in a barrel of mixed sizes. This is not by any means the whole principle in proportioning aggregates, but it is a long step in the right direction to insure that, when combined, the mixture of sand and gravel, or sand and crushed rock will be uniformly graded from fine to coarse. If this principle is applied the cabalistic ratio of one, two, four may be very much altered. Unfortunately, just as soon as we add water and cement, the problem is considerably complicated by several interdependent variables and what we are striving for is a dense concrete after the material has hardened, which is quite a different

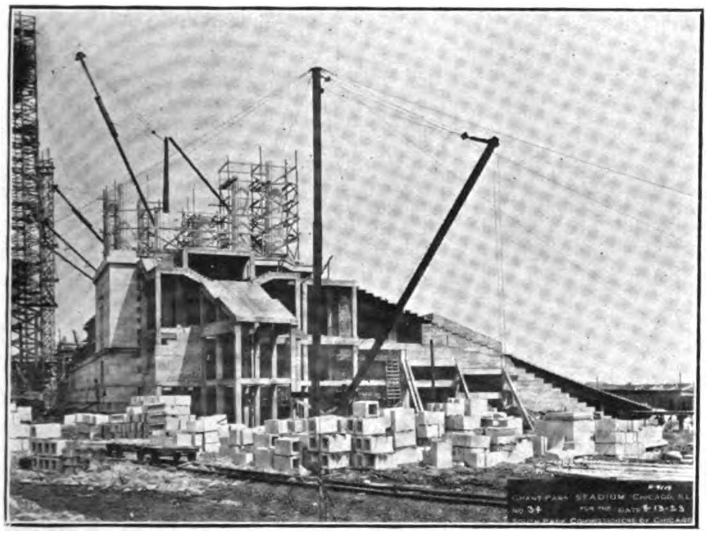
This stadium began to go to pieces before it was completed. The view was taken on the bleachers.

matter from the density of a combined aggregate. We can, however, specify that each aggregate be uniformly graded from fine to coarse, and this can be easily checked by a simple sieve analysis. The ideal ratio of sand to crushed stone is then closely approximated by the use of the "finess modulus" combined with a little practical checking in the field.

Mixing, Transporting, and Deposition.

The next step is the mixing, transporting, and depositing of the plastic concrete. In the first operation the most important factor, provided that the concrete is properly mixed, is the water control. Formerly, we were content to leave this question en-

tirely out of our specification, although certain engineers, particularly in France, had long realized the weakness caused by the use of excessive quantities of mixing water. In 1918 Professor Duff Abrams gave us definite data as quantitative guides showing that, other things being equal, the relative strength of concrete mixtures could be accurately predicted as a function of the water-cement ratio. This data was indisputable and the so-called water ratio, that is the ratio of water to cement, became a criterion of strength accepted by all concrete specialists.



Construction View of Grant Park Stadium. Holabird and Roche, Architects.

But even now, after ten years, it is only upon the more important operations that this principle is reflected in specification and field supervision.

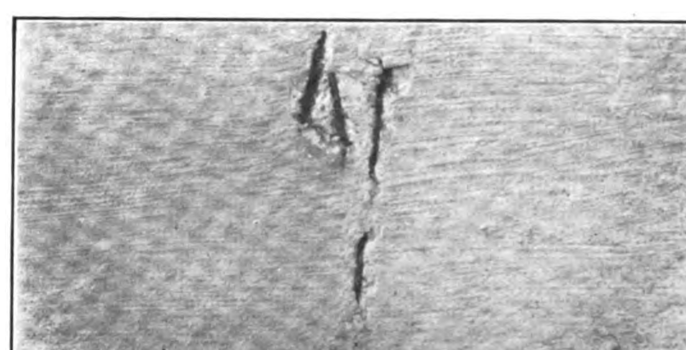
To the layman it would seem very easy to control the water added to a batch of concrete while it is passing through the mixer, and automatic measuring devices have been on the market for years. But difficulty arises due to the fact that the fine aggregate, usually sand, varies considerably in water content. To make the matter worse, the addition of water causes the sand to increase in volume, sometimes as much as one-third for the addition of only four or five per cent by weight of water. This situation results in a constant change of proportions, which tends to make an automatic water control often worse than none at all. To meet this condition we sometimes measure the sand in a submerged state as in the "inundator" and sometimes we carefully proportion cement and water, as in the Ahler's Strength Regulator, resorting to drying tests in order to determine the amount of water in the sand, which is then offset by adding less water in the process of mixing and by correcting the sand content to allow for the effect of the water upon its volume.

Satisfactory control requires frequent tests of the plastic concrete such as the "slump test," a means of gauging the relative workability of the different batches by observing the amount that a wet mass, taken from the point of deposit in wall or floor and placed in a metal mould, settles down or slumps after the mould is removed. The correct specification and control of the water content in concrete would probably do more than any other single factor to prevent poor construction, as we gain strength, abrasive resistance and impermeability by the limitation of water up to the point where the mixture becomes too dry for proper placement. If the profession would insist upon the recommendations of the American Concrete Institute in regard to this subject, much inferior work could be avoided.

The transporting and depositing of concrete are primarily matters of field supervision, but should not be omitted or slurred in the specification. The present tendency, on building operations, is to raise the concrete by hoist and tower and to distribute by buggy rather than by chute. The "spouting" system does not appear to be used quite as widely as formerly. The means of transportation from mixer to forms, however, is a matter of economics, as any means may be considered acceptable, from the viewpoint of the engineer, provided there is no separation of the materials and the concrete arrives at the point of final deposit in a homogeneous mass. The depositing of concrete is a simple procedure provided that it is correctly proportioned, mixed and transported, arriving at the forms in the proper consistency to flow into the available spaces. Ordinarily spading only is required except in very confined sections, such as occurred on the concrete boat work during the war, where an air hammer was used to advantage. Some effective means, however, should be employed to guarantee that no voids, or so-called "honeycomb" will appear in the finished work. This is a particularly important matter if the mixture has been made as dry as possible, but the additional labor in depositing will be more than offset by the greater strength of the concrete or, for a required strength, by the saving in cement made possible by the use of less water.

Laitance, and Construction Joints.

Another matter that merits particular attention when depositing concrete is the avoidance of laitance, a white chaulk-like substance which forms as a layer on top of newly-poured concrete. On all extended operations it is necessary to have some construction joints which are divisions between the work of consecutive days. In the case of floor slabs, design requirements dictate the most suitable sections for such joints, but in retaining walls they are usually placed where convenient, and if each course of material is separated by a layer of laitance, such soon becomes a plane of weakness, facilitating the percolation of water. Many walls now standing are disfigured in this manner, although prevention is simply a detail of careful supervision. If the concrete is comparatively dry when poured, less laitance will form and what does occur can be easily removed with wire brushes before continuing contiguous work.



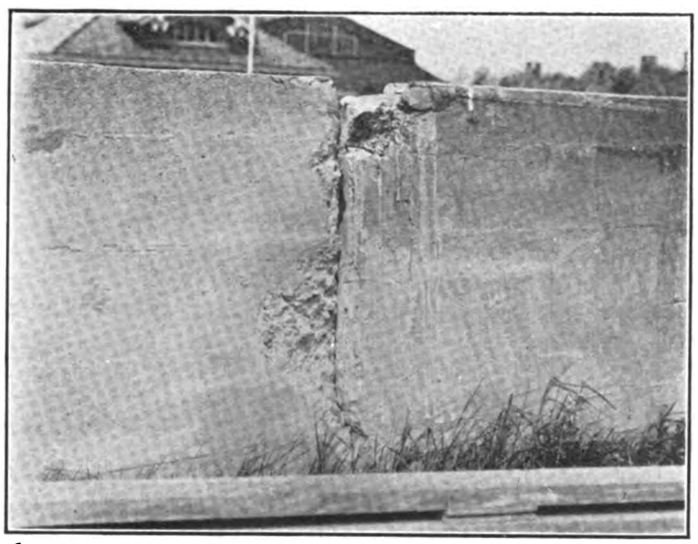
This view illustrates the rusting of steel reinforcement when not properly protected by concrete.

When building a steel structure we take great care to protect the steel from corrosion. This same principle should be as conscientiously followed in the case of concrete reinforcement and the tie-wires occasionally employed for retaining the forms in place. Insufficient insulation and the consequent progressive rusting of the reinforcement is another fault to be checked against incompetency in the field. It seems hardly believable that tie-wires would be left exposed so near the face of a wall that each would identify itself by a gradually increasing rust

spot, and yet this was done, only a comparatively short time ago, on what should have been one of the most monumental structures of America.

Importance of Careful Curing—Danger of Frost.

When the concrete has been deposited, the next step is to provide for its proper curing. A saying of Professor Abrams is to the effect that in mixing concrete as little water as possible should be used and as much as possible applied during the curing process. This is reflected in the practice of most builders as far as roads, floors and sidewalks are concerned, but greater attention should be given to providing moisture on other types of work. Exhaustive data prove that if concrete is allowed to dry out and remain dry before adequate hydration of the cement has taken place, it will attain only a small proportion of its possible strength. This fact is responsible for much of the difficulty experienced in the use of Portland cement stuccoes, which require the greatest care in curing and should be thoroughly drenched twice a day for a week or ten days after application.



Partial failure due to forgetting the contraction joint between post and panel.

There is an old saying that heat is the fifth ingredient necessary for the making of concrete. No contractor will deny that there is a possibility of injury if newly cast work is allowed to freeze, but many still make a compromise with good practice by providing only the most inadequate protection for work done in freezing weather. It is not a question of an ounce of preventive being worth a pound of cure. The only alternatives are prevention or disaster. Freezing of fresh concrete may ruin it for all time, and alternate freezing and thawing is sure to do so. There are cases where concrete has frozen immediately upon deposition, forms have been left in place until spring, and the resulting work has been accepted as satisfactory, but experience would appear to indicate that more or less injury probably occurred, and every winter has its crop of total disasters and partial failures due to the action of frost on newly poured concrete.

A few years ago in a New England City a large section of a concrete floor was cast during the early winter. The outside temperature at that time, or shortly after, was below freezing, and adequate protection was not provided. The design hardly conformed to best practice, but would undoubtedly have satisfied the conditions of occupancy if properly executed. In due time the forms were removed and attention was given to other parts of the building. The floor remained in place for about two months until Friday, the 13th of February, when it came down. No one was killed but the occurrence was annoying to all concerned, particularly to a couple of men who were working on the floor at the time. Concrete weighs about one hundred fifty pounds per cubic foot, and when a slab drops it usually goes through to the basement, carrying away everything beneath it.

Effective Precautions Against Cold.

There is no simple panacea for frost action. We have plenty of patented medicines and their advocates assure prospective clients that a quart of this or that concoction, placed in each batch of concrete, will insure against injury. Many of these compounds, in fact most of them, have some value either by reason of quickening the set of the cement, thereby lessening the period of extreme vulnerability, or of lowering the freezing point of water. Their use may be justified in weather which is merely frosty, but for exposed work in northern latitudes, executed in real winter weather, they are about as valuable as a cup of coffee to replace an overcoat.

The practice of all the foremost companies of America engaged in reinforced-concrete work bears out the statement that real winter operations should be enclosed and heated. The mixing water is raised to a temperature of about one hundred forty degrees Fahrenheit, the aggregates are warmed by the use of steam, and new work is completely enclosed by canvasses or other effective protection. Heat from salamanders, or steam is applied for a period of at least four to six days after pouring, according to the severity of the climate and the character of the work.

There is a widespread belief among field men that all is well if concrete does not actually freeze. They fail to appreciate that if the temperature drops toward freezing the rapidity of hardening lessens. This fact is the cause of many failures. In warm weather we might plan to strip a concrete floor at an age of seven days, when it would be expected to develop about half the twenty-eight day strength used in the design. This strength would be adequate, provided that construction loads were properly cared for and no unsupported concentrations brought down from the floor above. If instead of an average temperature of seventy degrees Fahrenheit during the seven days of curing, the average of day and night temperature had been forty degrees Fahrenheit, although actual freezing had not occurred, the strength of the floor would approximate only one-third, instead of one half, of the twenty-eight day strength. Stripping under these conditions, combined with a little carelessness in placing a pile of tile or brick on the new work, would probably be sufficient to bring it down or at least to cause serious injury, and the superintendent would exonerate himself by saying that "It never froze!"

Integral Waterproofing—Effect of Climatic Variation.

Another interesting branch of this subject is that of integral waterproofing. Concrete properly constructed has a high resistance to the passage of water. Six-inch walls have been known to withstand a head of over twelve feet. A domestic water tank was constructed some years ago with walls four inches thick and successfully withstood a head of six feet. No waterproofing was used in either case. On the other hand, the type of concrete generally delivered by the small contractor will hardly keep rain water out of a cellar. It all depends upon the quality of the work. The subject of integral waterproofing compounds has developed, from time to time, considerable discussion of a somewhat acrimonious nature and it is difficult to make any general statements which can be applied to individual problems. We will probably be safe in saying, however, that really good con-

(*Continued on page 42*)

Electricity Important in Prosperity

Has Enabled Power Supply to Keep Pace with Development of Industrial System by Furnishing Ideal Medium of Distribution

By Prof. Archer E. Knowlton

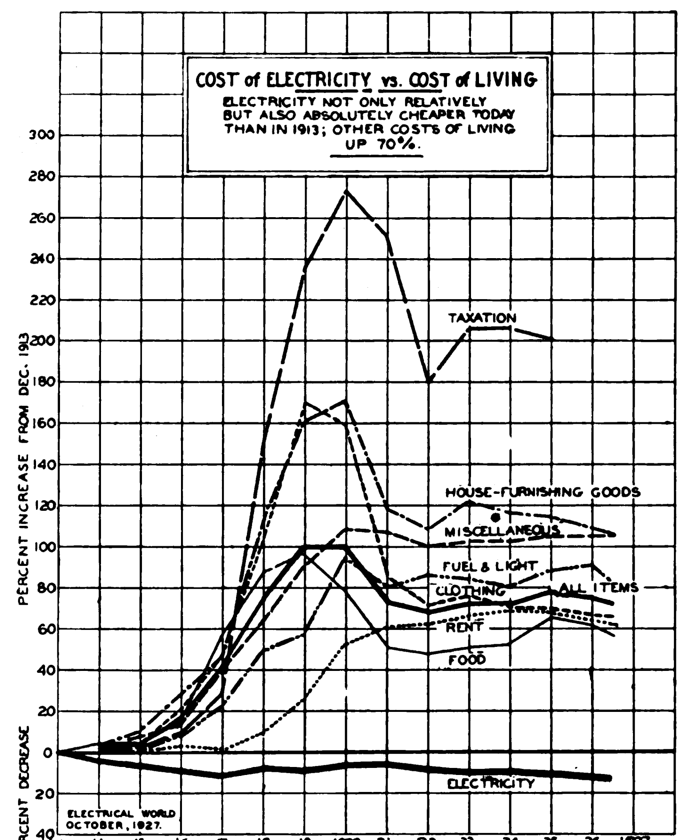
We are well aware that human progress in the past century or century and a half has been more rapid than for all the rest of recorded history. We know that we are living in a remade world and we also know that today our nation leads the rest of the world in wealth and in general well-being of its populace. It has been estimated that in 1781 the wealth of the world was about one hundred billion dollars after forty centuries of slow accumulation of reserves beyond current living consumption; in 1925 the world wealth, after one hundred and forty years of steam power and forty-five years of electric power and industrialism, was estimated to have increased one-hundred fold. The United States is credited with one-half the present world total. National wealth is but one of the many possible measures of human progress and well-being, but comparisons of the standards of living of past generations, the increased diffusion of wealth among all classes, the multiplied opportunities for individual attainment,—all leave us convinced that the world in which we live is not only different but immeasurably better.

What agencies have contributed to this progress and where does electricity stand in the list?

The present period is often called the Industrial Age, an age in which we multiply human effort by employing mechanical and electrical power in industry and by intensive organization and large-scale production convert our natural resources into products of trade. This whole system is so prominent a factor that economists and even historians tend toward the present rating of nations less in the old terms of their dynasties, conquests, colonizations, treaties and tariffs and more in terms of their reserves of natural resources and their inventive genius and productive capacity in converting them to the commodities of trade. In current analyses of national economic status gold reserves give way to coal and water power resources. On such a basis, the future of our own country seems pre-eminently established because we have to our credit one-half the total of the world's coal reserves and one-sixth of all the world's potential water power and this with a population only one-sixteenth the aggregate and an area even smalled in proportion.

The combination of natural resources and capacity for adapting them to our expanding needs has resulted in an industrial structure in which it is possible to pay real wages (not mere dollars per week) which in turn establish a purchasing power that can well be sensed when we see reported that we Americans own 85% of the world's automobiles, talk over 65% of its telephones and ride over 35% of its railroad mileage. Narrowing the study to the more intimate and exacting expenditures of the American worker, we find that his food costs him 40% of his earnings, whereas the European worker expends 60% to 65% of his wages for sustenance. Clothing and housing amount to about the same percentages for both groups, but it is to be noted that the American worker is much better housed and more elaborately if not better clothed. After taking into account other necessary outlays we find that our own workers have a much greater margin above the expenditures for the necessities of life. This margin is available for savings and investment, for travel and recreation, longer periods of education of his children, and such near-necessities as motored vehicles and battery-less radios. In short, dollar wages have doubled since 1913, while the cost of living decently is only 70% higher than before.

There is practically but one explanation for this whole situation and that is the enhanced productiveness of the worker in American industry. This increased output per worker in turn hinges upon the amount of mechanical and electrical power applied in industry to supplement, supplant and extend into hitherto unattainable levels the muscular efforts of human beings.



To show the degree of increase in productiveness, F. R. Low, editor of *Power*, in a recent editorial quotes the following from a statement prepared for the Iowa State Board of Education by Arthur Huntington:

> "In 1890 one man produced about half a ton of coal; today he produces about four tons and the machinery is developed to increase this to twelve tons.
>
> "During the same period the following increase in output per worker has taken place:
>
> From 100 sq. ft. of lumber to 750 sq. ft.
> From 500 lbs. of iron to 5,000 lbs.
> From ¼ pair of shoes to 10 pairs
> From 20 sq. ft. of paper to 20,000 sq. ft.
> From 55 sq. ft. of glass to 3,000 sq. ft.
>
> "An expert nailmaker used to make 5 lbs. of nails in 12 hours. The output in the nail industry today is 500 lbs. per day of 8 hours.

"Of course, this gain is not all net. Human labor is necessary to make the machines that are used up in the generation, transmission and application of this power.

"But it needs no argument to show that power has made and is making the work of the world easier, increasing the purchasing power of a day's work and making possible a lot of comforts, conveniences and advantages that were not imagined by our forbears."

The total power in industry in the United States amounts to about four horse-power per worker; this is twice as much as in Great Britain, four times as much as in France, and twelve times as much as in Italy. The margin between wages and expenditures for the necessities of life stands in about the same proportions as the power employed per worker in the different countries. The indispensability of power in our present scale of production is seen in the striking statement that all the workers in the world "working like slaves for us from sunrise to sunset, could not perform for us the work that is being done by power-driven machinery."

The Industrial System.

Power application has been accompanied by revolutionized methods of production and these, with the means for translation of people, of goods and of ideas, make up the fabric of our industrialized civilization. In other terms, the four components of our Industrial System are: the Factory System, the Transportation System, the Communication System, and the Power Supply System.

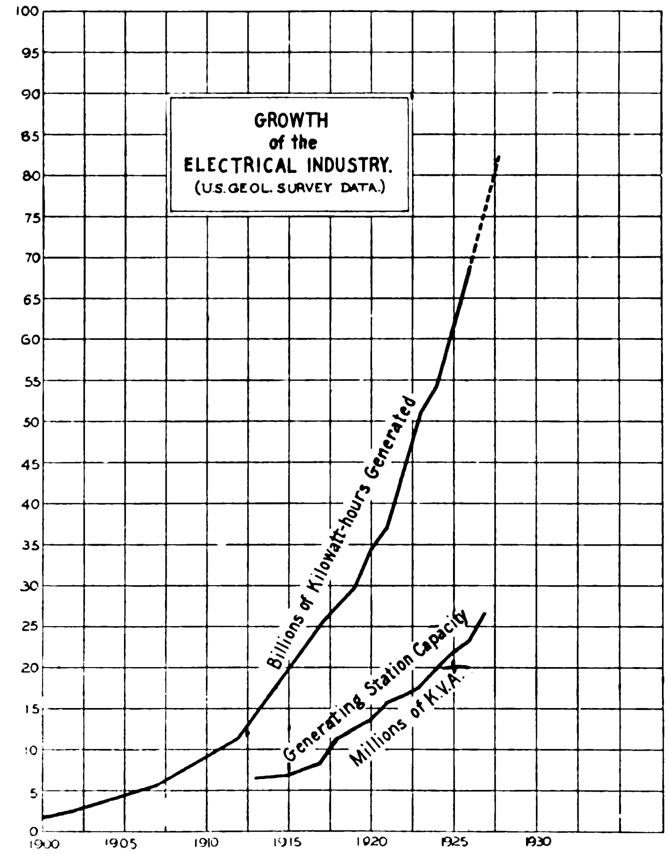
The Factory System is admittedly in an advanced stage in respect to (1) the improvement in management methods and organization for production, (2) the employment of mechanical and electrical power to the production process. It stands out prominently, of course, as the most evident factor in increased productivity and the consequent diffused prosperity. But without the other three components it would be powerless and perhaps could not even exist in anything like its present development.

The Transportation System, principally railroad facilities, had its inadequacy revealed during the peak period of the war,—inadequacy largely in motive power, in terminal facilities (rather than in main line trackage), and in means for more expeditious handling of traffic in competition with the motor vehicle. Both truck and passenger automobile, private as well as public, have created a new set of transportation possibilities and the resulting problems are gradually being solved by the railroads. Railroads in congested areas, roads with heavy grades and heavy freight traffic, roads with high density of passenger traffic have electrified to advantage and many others can profitably do so as soon as their credit standing progresses to the point where the financing can be effected economically.

The Communication System, consisting principally of the postal service and the various wire and wireless systems of telegraphy and telephony, provides a universal national service and an international service that is universal except in the field of telephony and even that is emerging from the experimental stages. We are looking forward to the realization of greater possibilities in the field of radio, in wire and wireless transmission of pictures, radio movies, television, etc., but the services already perfected justify the statement that the communication system as a whole is the most advanced of the group of four comprising the industrial system.

The Power Supply System.

The distance to which mechanical power can be transmitted economically by shafts and belts is limited to small values, and the amount which can be transmitted is also small. Water under pressure could probably be used fairly satisfactorily as a medium of transmission over distances of the order of 20 miles, but the feasible power limit would be not more than about 5,000 horse-power; the efficiency would be good, but the investment cost and price of power high. Compressed air could also be used for similar distances to carry more power with considerably lower investment and a lower cost per horse-power year. These possibilities never became realities because a new medium of power distribution appeared on the horizon,—electricity.



And the former agencies are now all far surpassed by electricity. Over 100,000 horse-power is being transmitted electrically over a single line a distance of 235 miles and greater amounts and distances are feasible when circumstances demand them. The investment costs per horse-power are much lower than by any of the other methods of transmission and the cost per delivered horse-power year is the lowest. These economic superiorities combined with greater ease of control of the power, greater flexibility in use, reduction in stand-by losses, and above all the chance to produce the power where cheapest and use it wherever and whenever wanted have established the electrical power industry on a plane of universality comparable to that of the Transportation System and approaching that of the Communication System. The rate of its growth from the beginning in the 80's has been one of doubling during each new five-year period. Prognostications for the next decade or two point to a continuance of this rate of increase and plans for additional generating station capacity and for systems as a whole are being made on the basis of this growth factor. Industry and home will both use more electric power; the increased use will tend to justify still lower rates, especially if the load factor is improved by greater diversity in time of use by the different consumers.

The capital invested in the electric power supply business is now over $8,500,000,000, and an additional five or six billions will be needed during the next five years to finance the planned

(Continued on page 38)

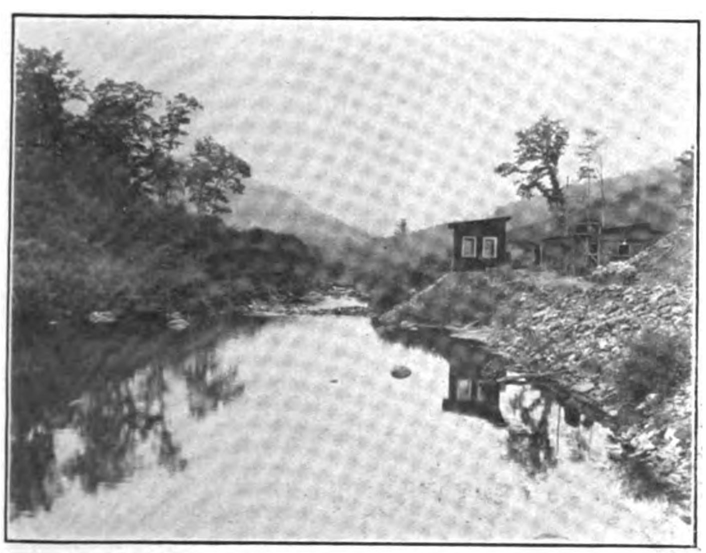
Shepaug Tunnel of Geological Interest

Engineering Project near Litchfield Completing Great Water System Uncovers Interesting Formations Revealing History of the Region

By Prof. William M. Agar

THE city of Waterbury began the construction of its public water system as far back as 1869. Naturally the original work had to be added to from time to time, to keep pace with the growth of the community, and by 1907 it was seen that the city would have to reach far out beyond the zone that had so far been used, if a sufficient supply of potable water was to be assured.

After two attempts to gain control of supplies nearer at hand, which were blocked in the legislature by the communities involved, it was decided to reach out to the watershed of the Shepaug River above Woodville, a sparsely inhabited and wooded region three miles west of Bantam Lake, and to carry this water more than seven miles across the country into the valley above the Morris Reservoir, the farthest northern extension of the already existing water system. This necessitated drilling a tunnel



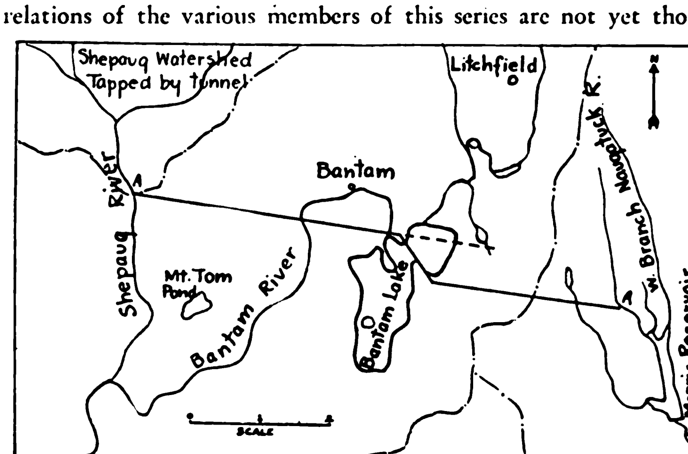
View looking up the Shepaug River Valley, soon to be turned into a reservoir. Tunnel entrance to the right of the shacks. Photograph by B. H. Walden.

38,236 feet long, south of the town of Litchfield, all but 1,270 feet through solid rock. The tunnel, now completed, lies nowhere more than a few hundred feet below the ground; it comes to the surface where it crosses the Bantam River valley south of Bantam Village, and passes out of bed rock again under a swamp one-half mile west of that point.

The tunnel was drilled from four headings without sinking any shafts. The stretch between the Bantam River and the outfall end is about five miles long and includes two sharp angles, but these various sections holed through in perfect alignment. *The whole operation was an engineering feat that merits a far longer description than can be given to it here.* From the point of view of a geologist, a tunnel is merely a long section of rock exposed by man instead of by nature. It is dark, and the walls are generally plastered with mud where the blasting has thrown back the finely powdered rock. In spite of these handicaps it can be very useful. *This particular tunnel presents a very unusual opportunity to study the complicated geology of the region.* It gives the longest continuous section available and exposes contacts between formations that are not otherwise observable.

The rocks are all metamorphic rocks. That is to say, they have been changed from their original condition by means of high temperature, pressure and heated solutions at great depths within the crust of the earth. They were then brought to the surface through the wearing away of thousands of feet of overlying rock by the ordinary processes at work upon the earth's exterior—temperature changes, frost, chemical decay of rock, running water, the wind, and moving ice. Since they are all thoroughly metamorphosed, even those parts that were originally deposited as accumulations of sands and muds and formerly may have contained organic remains, are now devoid of fossils; so the greatest aid to the determination of age and structure is lacking. The outcrops of these rocks are few and scattered. They are separated by areas covered with sand, gravel, and boulders. The surface is forested, grass grown, or under swamp and lake; so that the mere labor of finding outcrops is often very great, and the aid to such a search furnished by a seven-mile tunnel is easily apparent.

Metamorphic rocks underlie the whole of western Connecticut as well as the region under discussion. They are marbles, various schists and gneisses, local areas of granite gneiss only slightly metamorphosed, and small but numerous pegmatite dikes. The relations of the various members of this series are not yet thor-



Map showing watersheds in the area discussed. —.—.—, Watersheds. AA, Tunnel line. ————, Line of diamond drill holes.

oughly understood, and consequently the history involving deposition, intrusion, metamorphism, and erosion, is far from completely unravelled, but a brief survey of this history will be presented after describing the formations in the region of the tunnel.

The Rocks Exposed in the Tunnel.

The western 3,000 feet of the tunnel, from the Shepaug River east, cut through a coarse and contorted mica schist of unknown

age called the Berkshire schist. The materials composing this rock were probably first laid down as argillaceous sediments, but have since been so compressed by forces acting in an east-west direction that they were thoroughly recrystallized into a quartz, biotite (black mica) schist with locally enough feldspar to be a true gneiss. As is usually the case under such conditions, the biotite developed with the cleavage faces of separate individuals parallel to each other and normal to the direction of pressure, and the quartz formed as grains and groups of grains between the mica plates with the long axes parallel to the elongation of the mica. This arrangement of minerals gives the rock a rough banding or foliation in planes that dip steeply to the west. Some of the mica plates are bent and broken, and part of the quartz is ground up into small fragments, showing that a second period of pressure has acted upon the rock thoroughly recrystallized by the first.

Irregular contact between the Berkshire schist and a pegmatite dike into the tunnel, 1000 feet east of the tunnel entrance at the Shepaug River. Two drill holes are shown in the schist at the left. (Photograph by B. H. Walden).

Dikes of pegmatite—an igneous rock with the composition of a granite but with crystals of large size—have insinuated their way between the folia of the schist or cut diagonally across it. These dikes lie nearly normal to the tunnel and vary in thickness from a few feet to upward of 200 feet.

East of the schist the tunnel passes through a green and white or dark greenish gray granular rock often lacking the foliation characteristic of the mica schist but sometimes possessing it to a marked degree. This is the Brookfield Diorite, an igneous rock made up of hornblende, biotite, plagioclase feldspar, and a little quartz apatite, and titanite which continues with variations for the next 20,000 feet of the tunnel. The diorite is an igneous rock; that is it was formed by the cooling and crystallization of molten rock magma in place. This magma worked its way up from below pushing aside the rocks already present or arching them up and possibly melting and assimilating parts of them. It is necessarily younger than the rocks which it has intruded.

Some parts of the diorite retain the texture which they developed as the individual minerals crystallized out from the molten mass. This is the texture of crystallization in which the first minerals to form develop good crystals, and the later ones are progressively interfered with by those already present until the last ones must fill in the remaining spaces. Other parts of the diorite are strongly foliated and a great deal of the mica, biotite, oriented as in the schists, has developed in response to the pressure.

The diorite is intersected by a number of dikes of granite, diorite porphyry—a rock with the mineral composition of a diorite but with large pink feldspar crystals as much as three inches long set in a finer grained groundmass—and a tough, dark green rock composed mostly of hornblende and biotite.

The Brookfield diorite is further complicated by a considerable number of inclusions of the two schists that it intruded. Those of the Berkshire schist are confined to a zone within a thousand feet of the contact between the two rocks, but the inclusions of the Hartland schist are scattered throughout the tunnel from the marsh west of the point where it crosses Bantam River to the contact between the diorite and the Hartland schist at the base of Marsh's Point.

These inclusions are long, thin bands that retain the schistose character of the rock from which they were isolated but are somewhat more altered because they were at one time surrounded by the molten diorite magma.

East of Bantam lake the tunnel passes into the Hartland schist, the third and last formation that it cuts. This is a thick series of mica and quartz schists with rare bands of quartzite, and one ban dthat contains garnet and other lime silicates. The proof is clear in this case that the schist was derived from a series of sedimentary strata, shale and sandy shale, with rare sandstone layers and one band of calcareous mud. The quartz and mica schists alternate in a monotonous repetition for nearly two miles, and the bedding planes are preserved parallel to the foliation now developed in the schist. The texture is that of complete recrystallization. That is, the chemical elements in the minerals of the muds and sands have been reorganized into new minerals stable under conditions of metamorphism, and a completely crystalline rock has been formed from the clastic or detrital material of the former stage. The change stopped at that stage, however, and there is no sign of still later squeezing as is the case in the Berkshire schist.

The Hartland schist is cut by a large number of pegmatite dikes that, for the most part, parallel the foliation, and in some parts of the tunnel are as common as the alternating bands of mica and quartz schists themselves.

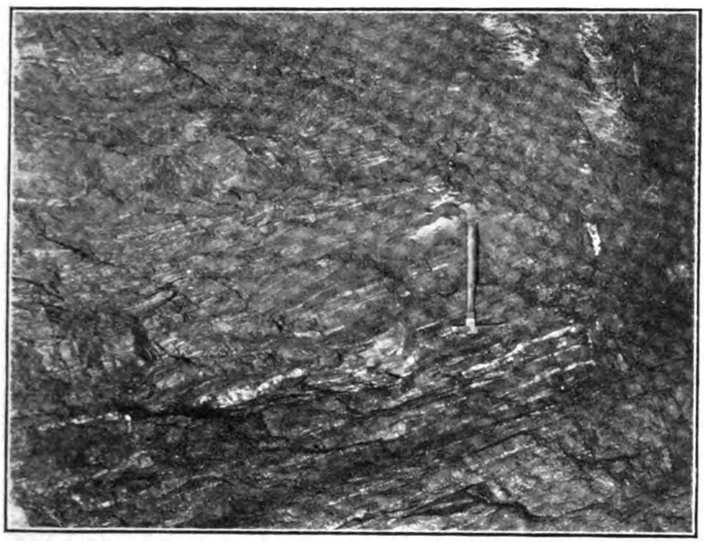
View showing the massive character of the Brookfield diorite at the entrance to the tunnel east of the Bantam River crossing.

The foliation planes are everywhere parallel to the bedding, and they both dip uniformly to the west with an average inclination of forty degrees.

It is interesting to see what can be told of the thickness of the series of sandy muds and muds laid down some time previous, then hardened into rock and finally metamorphosed into the present schist series. If the series in the tunnel were one thick series all tilted one way it would represent an original accumulation over 8,000 feet thick—and this but a small part of the whole Hartland schist. If, on the other hand, it represents a repeated series of folds planed off by erosion and intersected by the tunnel far from the ends of the folds—i.e., where the folia-

tion and the bedding coincide,—there may be any amount of repetition. This latter case is almost certainly the true one, but a series of easily recognized schist different from anything else in the tunnel, hornblende, sericite and garnet schists about one thousand feet thick—probably originally limy muds—lies near the center of that part of the tunnel east from Bantam Lake. This series could be easily recognized if it were repeated anywhere in the tunnel, but it is met with only once. If it exists just beyond the tunnel section the thickness of the series would still be more than 3,000 feet.

It has been pointed out that the greater part of the rocks described above possess a foliation. That is the common structure of the region, and these foliation planes maintain a wes-



Pegmatite lenses parallel with the flat dipping foliation of the Hartland mica schist, 1000 feet east of the southernmost corner in the tunnel. (Photograph by B. H. Walden).

terly dip throughout most of the area. In the Hartland schist they can be seen to be parallel to the old bedding planes of the sedimentary strata, but no such coincidence can be determined in the Berkshire schist because it lacks the variety of types that show original differences even after metamorphism. The foliation in the Brookfield diorite is never so perfect as in the schists, but is well marked in some parts of the rock.

Small faults are met throughout the tunnel. These are planes or narrow zones along which a differential movement of the two rock walls has taken place. At a point nearly one mile east of Bantam Lake there is one such fault that has caused considerable shattering and grinding up of the rock through a zone about ten feet thick. This is the largest one in the tunnel, but due to the similarity of the wall rock on either side there is no way to measure the amount of displacement that has occurred.

Additional Facts Discovered in Construction of Tunnel.

Besides the information concerning the bed rock discussed above, the construction of the tunnel and the diamond drilling that preceded it uncovered certain interesting facts concerning the thickness of the sands, gravels, and clays, that constitutes the soil cover of the region, and the contours of the bed rock surface that lies beneath.

The glacier that lay over this region for a considerable period in the recent geological past carried away most of the soil cover formed by weathering previous to that time and scraped off much of the disintegrated and decayed rock that was not yet soil. When the ice finally melted, it dropped the material it had formerly picked up as an irregular blanket of debris. As is generally true in glaciated regions, this mixture of sand, gravel and boulders of all sizes usually rests directly upon a fresh rock surface. One notable exception to that rule is well shown in this region. West of the mash that lies est of the Bantam River crossing, the tunnel passes through several hundred feet of rock similar to that on both sides of the area but greatly decayed. The depth to which this weathered rock extends is not known, but the fact that it exists where all other rock is unweathered shows that there was an unusual depth of weathering in the first place, probably because of the existence of a number of small faults that acted as passage ways for downward seeping surface waters, and some means of preventing the ice from gouging out the soft decayed rock. The explanation of the latter is found in the mass of Prospect Hill that lies immediately to the north and protected the area to the south from the full force of the ice.

Another interesting feature is the deep rock basin underlying the northern expansion of Bantam Lake. Diamond drill holes showed that the level at which the tunnel was to be drilled lay some distance above bed rock at this spot, even though the bottom of the lake itself was many feet higher than the tunnel level. A new set of bore holes drilled across the narrows of the lake showed a rock cover sufficient to allow the tunnel safely to follow that course, but exposed a narrow gorge in the rock that was completely hidden by the glacial sand and gravel and the lake silts forming the bottom of the lake. The ridge to the east of the lake, lying between it and Cranberry Swamp, was shown to be composed entirely of sand, gravel and boulders and to have no corresponding rock ridge beneath it. These features show that the Bantam River once flowed through a broad open valley north of the present narrows of the lake, through a constricted gorge in those narrows and out towards the south. The retreating ice left a barrier of sand and gravel at the southwestern end of the present lake, causing the river to fill the basin so formed, and spread a thick layer of material over the valley floor, leaving the present very shallow Bantam lake perched above the old irregular surface and causing the Bantam

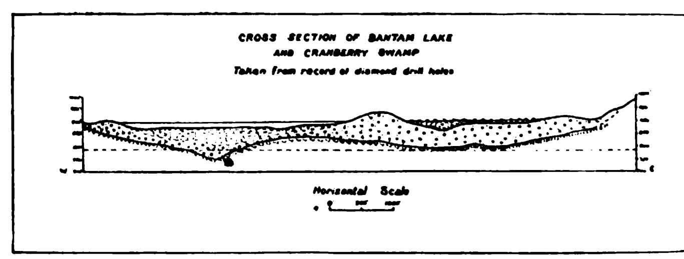


FIG. 3—Cross Section of Bantam Lake and Cranberry Swamp

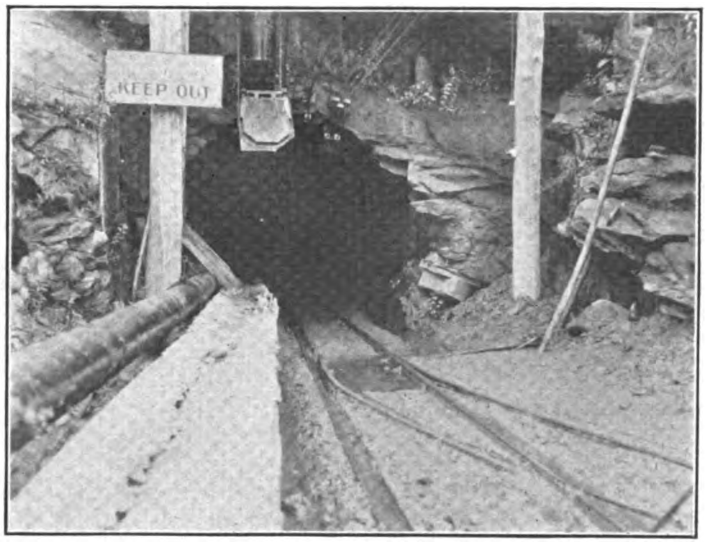
River to seek a new outlet from the lake only a mile from where it enters the lake. The lower level of the bed rock above the narrows cannot have been caused by the river itself and must be due to overdeepening of that basin by the ice which plucked out parts of the rock or may merely have scoured out the products of weathering that had proceeded to a greater depth at that point.

The Geological History of the Region.

The preceding passages give a brief resume of the more important geological facts that were learned in and about the tunnel itself. This is a very small part of the western upland of Connecticut, so that an attempt to reconstruct the sequence of events must necessarily lead us beyond this restricted area. The geology of the whole region is exceedingly complicated, and our knowledge of it is far from complete and is subject to possible radical revision, but a broad survey of the chief events is possible.

The first event of which we have any record was the deposition of thick beds of sedimentary material in an arm of the sea

that overlay western Massachusetts and at least the northwestern part of Connecticut in pre-Cambrian times. The extent of this sea and consequently the position of the shore lines and the higher lands that furnished the sediment cannot be told. All that we know is that the oldest rocks of the region were originally sedimentary rocks, and that they rest now, not upon the base upon which they were laid down, but upon igneous rocks chiefly granites, that welled up from below and destroyed the base and probably much of the sedimentary strata themselves. Mountain ranges trending northeast and southwest were formed by the folding and crumpling of the existing rock, probably at the time when the intrusions took place, and the sedimentary rocks undergoing this folding and intrusion were changed to schists and the intruded granite to a granite gneiss. There followed a long period of erosion during which the lofty peaks of



View of the entrance of the tunnel east of the Bantam River crossing.

this range were worn down nearly to sea level, and the originally deep-seated core of igneous rock, containing shreds and fragments of the sedimentary strata it had intruded, was exposed to the light of day.

Later the sea once more passed over much of the area and lapped the worn-down roots of what had been a mountain range. More sedimentary matter was deposited along the shores and out in the shallow depths of that sea. These new sedimentary strata were now metamorphosed and squeezed up into another range of mountains along with the older rocks. In fact, several such movements must have affected them before the final great upheaval at the end of the Paleozoic Era that raised the Appalachian ranges from Newfoundland to Alabama. Another period of erosion followed, and some of the material then worn away is preserved in the Triassic sediments of the Connecticut Valley. The next event, in part overlapping on the last, was a faulting and a general uplift of the region which initiated another long period of erosion that brought most of the eastern states down nearly to sea level and left a vast, almost featureless plain from the Atlantic ocean to the Mississippi valley.

The sequence of events so far is fairly clear, but the accurate dating of some of these events is at present impossible. The first recorded mountain making was clearly in pre-Cambrian time as before stated, but the next deposition of sediments that included the limestones of the Housatonic valley and the Berkshire schist overlying it—the rock that forms the walls of the western part of the tunnel—may have been in pre-Cambrian times or partly in the Cambrian and partly in the Ordovician periods—that is

(*Continued on page 40*)

OUR CONTRIBUTORS

¶ *William MacDonough Agar, who describes in this issue the Shepaug Tunnel, is Assistant Professor of Geology. He received three degrees at Princeton; B.S. in 1916, M.A. in 1920, and Ph.D. in 1922. Prior to his appointment to the Sheffield Scientific School as instructor in 1923 he was connected with the Anaconda Copper Company's Geological Department at Butte, Montana.*

¶ *Harold Saxton Burr, who writes in this issue on Medical Education, is Associate Professor of Anatomy in the Yale Medical School. Professor Burr graduated from the Sheffield Scientific School in 1911 and received his Ph.D. here in 1915. He has been connected with the University ever since his gradution.*

¶ *Theodore Crane, whose article on Concrete Building Construction appears in this issue, has been Associate Professor of Building Construction in the Sheffield Scientific School since 1924. After receiving his C.E. at Princeton in 1908 he has had wide experience in this particular field, and is the author of the recent book, "Concrete Building Construction."*

¶ *Treat Baldwin Johnson, '98 S., who discusses the progress of chemical research in tuberculosis, is Professor of Organic Chemistry and has been a trustee of the Sheffield Scientific School since 1920. Professor Johnson received his Ph.D. from Yale in 1901 and has been connected with the chemistry department ever since his graduation.*

¶ *John Johnston, who submits "Wiliard Gibbs—An Appreciation," is a graduate of St. Andrews (Scotland), 1903, where he also received the degree of Sc.D. in 1908. He was honored with the degree of M.A. by Yale in 1919. Mr. Johnston was chemist in the geophysical lab. of Carnegie Institute from 1908 to 1916. He served as Sterling Professor of Chemistry until he left the University last year to become Director of Research in Technology for the United States Steel Corporation.*

¶ *Archer Eben Knowlton, who discusses the relation of Electricity to Prosperity, received his degree of B.S. at Trinity in 1910, his M.S. there in 1912, and his E.E. from the Sheffield Scientific School in 1921. He was appointed instructor in Electrical Engineering in 1919 and became Assistant Professor in 1922. He is also Electrical Engineer for the Connecticut Public Utilities Commission.*

¶ *Chester Ray Longwell is Associate Professor of Geology. He graduated from the University of Missouri in 1915 and received his M.A. there the following year. Upon leaving Missouri, he was appointed to the faculty at Yale and received the degree of Ph.D. in 1920, becoming Assistant Professor the same year.*

¶ *Professor Charles F. Scott, who writes the editorial in this issue, received his B.A. at Ohio State University in 1885. He was made Consulting Engineer for Westinghouse in 1904 and had been with that company for twenty-three years when he left in 1911 to become Professor of Electrical Engineering here. In addition to holding honorary degrees from Pittsburgh, Stevens Institute, and Yale, Professor Scott has been a member of the Executive Committee of the American Engineering Council since 1921 and was President of the Society for the Promotion of Engineering Education in 1922. He has been head of the Electrical Engineering Department in the Sheffield Scientific School for several years.*

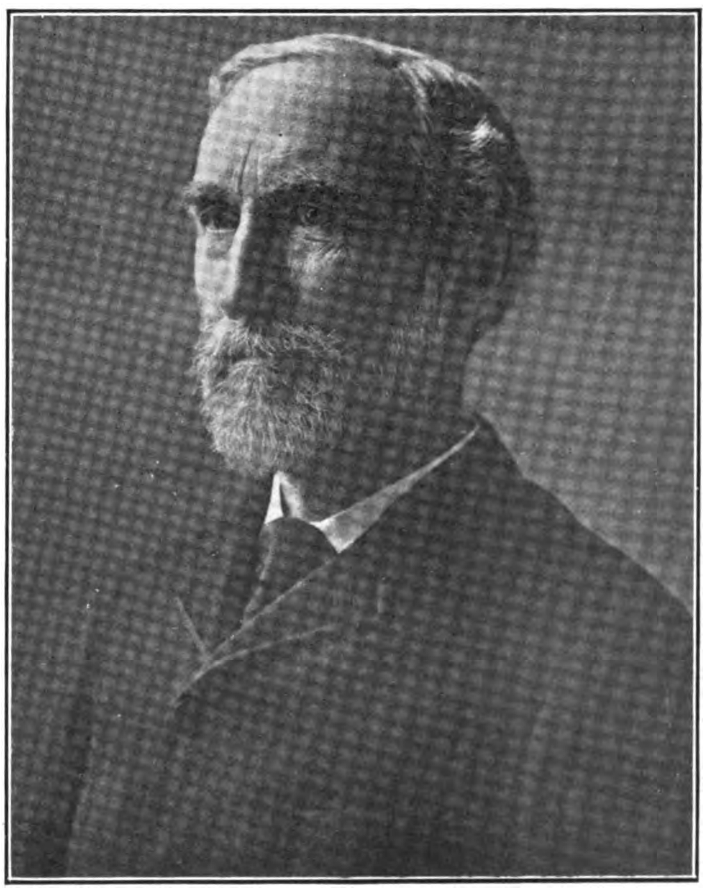
Josiah Willard Gibbs, An Appreciation

An Endeavor to Give Long Due Credit to Yale's Foremost Scientist—Gave New Life to the Study of Chemistry

By John Johnston

IT is somewhat of an anomaly that the fiftieth anniversary of the publication, in the Transactions of the Connecticut Academy, of the first part of Gibbs' great work on the equilibrium of heterogeneous substances should have been signalized in Holland by the publication of a Gibbs number of their chemical journal, the *Chemisch Weekblad;* whereas few, if any, in America took thought of the matter at all. It is furthermore anomalous that the contributors to this number should include besides the Hollanders, a Frenchman, a Canadian, a Norwegian, two Englishmen, but no American. Truly a prophet is not without honor save in his own country.

This is instanced in another way. Quite a number of foreigners visiting Yale have asked about a memorial to Gibbs, and have expressed astonishment at the reply that there is none, apart from a bas-relief on the stairway of the Sloane Physics Laboratory,—and this bas-relief is the gift of Professor Walther Nernst, of the University of Berlin. One visitor, a distinguished Swedish scientist, was not satisfied until he had laid a wreath upon Gibbs's grave. This is a condition of affairs which, it is expected, will soon be remedied by the establishment at Yale University of an appropriate memorial in the form of a Willard Gibbs professorship. Those appointed to this professorship would, it is contemplated, be men from other institutions qualified to give a course of lectures, extending over one or two terms, in some branch of Chemistry, Physics or Mathematics, particularly in those fields especially associated with the name of Gibbs; and they would be considered as temporary members of the faculty giving courses regarded as a regular part of the university curriculum. The rotation of eminent men, from many countries, each an outstanding figure in his own line of work, would serve as an inspiration to faculty and student alike, and thus would constitute a continuous memorial to Gibbs.



Josiah Willard Gibbs.

At present one can merely adapt the epitaph to Sir Christopher Wren, "*Si monumentum requiris, circumspice,*" in suggesting that the visitor read Gibbs's papers and ponder their manifold practical consequences, both direct and indirect. But his most important papers are again out of print and difficult of access, as indeed they have been for a considerable fraction of the period since their first publication. This difficulty will soon be removed by the publication—arrangements for which are well under way—of an inexpensive edition of his works. But another difficulty remains, for Gibbs's reasoning is so rigorous that few people have been willing to study his works sufficiently to grasp their full implications; for to him "mathematics is a language," as he is reported to have stated in a faculty meeting engaged upon the Sisyphean task of determining the course of study to be pursued by the average student. This difficulty of interpretation may, it is hoped, be alleviated by the publication of a volume, or volumes, in which his work would be amplified and explained, with illustrations of its application to some of the multifarious experimental cases which have in the meantime been investigated; arrangements are now under way to have these essays written by those most competent in the special fields. This should serve to widen the appreciation of Gibbs's contribution to natural philosophy; for, particularly as regards many of the developments of great economic value, those who have benefited are quite unaware of the fact that without Gibbs's work these developments would not have been possible. Nor is it a case of which it may be asserted that someone else would have done it; this would be true with respect to isolated theorems, but only a genius of the first order could imagine and arrange the whole as a connected philosophy. It may well be remarked here that no mistake has yet been discovered in Gibbs's work—the accumulation of experimental observations has merely verified his predictions, and in no case run counter to them—though in the fifty years since publication many principles and theories of physical science then generally accepted as fundamentally true have proved to be incompletely valid or even erroneous.

Salient Facts About His Life.

Before endeavoring to set forth just what was achieved by Gibbs, let us recall the main facts of his life. Josiah Willard Gibbs was born in New Haven, February 11, 1839, the fourth child and only son of Josiah Willard Gibbs, Professor of Sacred

Literature in the Yale Divinity School, and of his wife, Mary Anna, daughter of Dr. John Van Cleve of Princeton. He entered Yale College in 1854, graduated in 1858, and continued his studies in New Haven until 1863, when he received the degree of Doctor of Philosophy, the title of his dissertation being "On the Form of the Teeth of Wheels in Spur Gearing." He then spent three years as a tutor, the first two in Latin, the last in Natural Philosophy, and in 1866 went to Europe, first to Paris, then to Berlin, and finally to Heidelberg, where at that time both Kirchhoff and Helmholtz were active. In 1869 he returned to New Haven and in 1871 he was appointed Professor of Mathematical Physics in Yale College, a position which he held until his death, April 28, 1903. Scientific honors of all kinds came to him; medals, degrees, membership in academies and other learned societies; and he was in correspondence with Kelvin, Clerk Maxwell, Boltzmann, and other contemporary European leaders in mathematical physics.

His Most Important Works.

In 1873, when 34 years old, he published in the Transactions of the Connecticut Academy two papers, one entitled "Graphical Methods in the Thermodynamics of Fluids," the other "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces;" and, following these, in 1876 and 1878, the two parts of the great paper "On the Equilibrium of Heterogeneous Substances," which is generally "considered his most important contribution to physical science, and which is unquestionably among the greatest and most enduring monuments of the wonderful scientific activity of the nineteenth century" (Bumstead).* His subsequent principal writings in the years 1881-1893 deal with multiple algebra and vector analysis (the latter finally published in 1901 as a treatise edited by Professor E. B. Wilson); with the electromagnetic theory of light, a series which appeared between 1882 and 1889; and lastly a work entitled "Elementary Principles in Statistical Mechanics," in which he returned to a theme closely connected with his work on thermodynamics. At his death were found a few fragments, intended as portions of a supplement to the "Equilibrium of Heterogeneous Substances;" these are published in the "Scientific Papers." It is of interest to note that one of the topics he proposed to treat is "entropy as mixed-upness," a point of view which during the last few years has been widely adopted.

Of his work, the classic paper on "The Equilibrium of Heterogeneous Substances" has exerted the greatest influence, in particular upon the development of chemistry; indeed, according to Ostwald, "To general chemistry he gave form and content for a hundred years." The Copley medal of the Royal Society was, in 1901, awarded to him as "the first to apply the second law of thermodynamics to the exhaustive discussion of the relation between chemical, electrical and thermal energy and capacity for external work." Larmor in the article "Energetics" in the Encyclopedia Britannica wrote: "His monumental memoir . . . . made a clean sweep of the subject; and workers in the modern experimental science of physical chemistry have returned to it again and again to find their empirical principles forecasted in the light of pure theory, and to derive fresh inspiration for new departures."

As an illustration of the succinct style in which this memoir is written—a style in which every word counts and no word is redundant—I quote the first paragraph:

"The comprehension of the laws which govern any material system is greatly facilitated by considering the energy and entropy of the system in the various states of which it is capable. As the difference of the values of the energy for any two states represents the combined amount of work and heat received or yielded by the system when it is brought from one state to the other, and the difference of entropy is the limit of all the possible values of the integral $\frac{dQ}{t}$ (dQ denoting the element of the heat received from external sources, and t the temperature of the part of the system receiving it), the varying values of the energy and entropy characterize in all that is essential the effects producible by the system in passing from one state to another. For by mechanical and thermodynamic contrivances, supposed theoretically perfect, any supply of work and heat may be transformed into any other which does not differ from it either in the amount of work and heat taken together or in the value of the integral $\frac{dQ}{t}$. But it is not only in respect to the external relations of a system that its energy and entropy are of predominant importance. As in the case of simply mechanical systems, (such as are discussed in theoretical mechanics), which are capable of only one kind of action upon external systems, viz., the performance of mechanical work, the function which expresses the capability of the system for this kind of action also plays the leading part in the theory of equilibrium, the condition of equilibrium being that the variation of this function shall vanish, so in a thermodynamic system, (such as all material systems actually are), which is capable of two different kinds of action upon external systems, the two functions which express the twofold capabilities of the system afford an almost equally simple criterion of equilibrium."

It ends abruptly with equation 700, which is in effect the correct equation for the electromotive force of what Gibbs calls "a perfect electrochemical apparatus," or a reversible cell; it comprises some 300 pages of close reasoning in which many important theorems are enunciated, and rigorously derived, for the first time.

His Genius Unappreciated.

To convey an adequate idea of just what Gibbs achieved is no easy task, as may be imagined from the fact that it took another genius of the first rank—Clerk Maxwell, who formulated electrodynamics, unified many phenomena apparently diverse, and was enabled to make predictions which have culminated in radio, if indeed they can be said to have culminated—to apprehend what Gibbs had done; and a period of a quarter of a century had to elapse before it was appreciated, except by a small number of outstanding men.

Many of you have formed some acquaintance—perhaps only a nodding acquaintance—with dynamics, and have learned painfully the way in which a body moves under certain conditions, e.g., in free flight, or down an inclined plane; or what happens when two bodies collide: these elementary calculations are always subject to the simplifying assumption that the slowing up due to friction may be neglected. The justification for this simplification is that the result is that which is approached more and more nearly as the frictional resistance is diminished indefinitely. These problems deal only with a single body, or at most with two bodies, and pay attention only to their mass or size, but not at all to their chemical constitution nor to any changes in them which may arise as the result of the motion or collision.

Now if one is to get a rational basis for foretelling if, and to what extent, chemical change will proceed in a system—this being in effect the task which Gibbs set himself—one has a very much more complex problem. For the smallest amount of material which we ordinarily deal with practically is comparable

* "The Scientific Papers of J. Willard Gibbs," edited by Henry Andrews Bumstead and Ralph Gibbs Van Name; 2 volumes, 1906. (Volume 1 now out of print).

to a teaspoonful of water, but this contains of the order of 10^{23} particles. This is an almost inconceivably large number; an illustration may help to show how large. If a being at the beginning of geologic time—say a thousand million years ago—had begun to count, not by units but by millions—one million, two million, three million, and so on—he would only now be approaching this number.

Extraordinary Accuracy in Complicated Formulas.

Thus Gibbs set himself the far more formidable task of formulating what would happen when very large numbers—to be reckoned in millions of millions of millions—of particles, and of particles of different kinds, in different states, solid, liquid, gaseous—are brought together; and what would be the effect, upon such a system of particles, of changes in the external conditions of temperature and pressure. He was examining the state of equilibrium of systems, and discovering how this state of equilibrium is influenced by change in the conditions to which the system is subject; but in this case again, to postulate equilibrium does not really limit the applicability of the results, for in an actual case we can make allonce for those factors which resemble friction in that they impede the processes of change. In other words, he was seeking a measure of the tendency of any system to change; the farther from equilibrium, the greater is this tendency, and it becomes zero only when equilibrium has been attained. To achieve this purpose he could not of course consider the particles individually, but had to use what are in effect statistical methods—to use as characteristics of the system quantities such as temperature or pressure which represent a statistical average related to the motion of the particles.

This kind of idea may perhaps be illustrated by an example familiar to you. The annual death rate in a stable community is a definite figure, which is now changing rather slowly, apart from some special cause such as a new epidemic. If we take it that New Haven has a population of 200,000 and a death rate of 15, we can predict that there will be close to 3,000 deaths in 1928; we cannot foretell whether any given person will die. This is the basis upon which the life insurance company makes its bet with you as to the duration of your life—a bet in which you can make a financial gain only by dying before your statistical expectation of life has run. In other words, this method considers the crowd, and not the individual; and the larger the crowd, the more uniform will the mortality be, and so the more certain are the results of this statistical method of inquiry. The number of marriages, divorces and births—the unions and disunions of individuals and their resultants—may be treated in a similar way, the whole comprising vital statistics. In a sense then Gibbs is considering vital statistics of atoms, the birth rate and death rate of each of the kinds of particle composing the system, and from this deducing what the stationary state of the system will be. And in his systems he has an advantage in that he is dealing with such enormous numbers of particles that the results, instead of being merely probable, are in fact certain. The great merit of this mode of attack is its freedom from assumptions of any kind—other than the laws of thermodynamics, the truth of which has been experimentally demonstrated so that any exception is extraordinarily improbable—in other words, its great generality; though this, on the other hand, renders more difficult the application of Gibbs's results to specific questions.

Gibbs then derives, by absolutely rigorous reasoning, equations in terms of these characteristic statistical quantities for each kind of particle present, equations which enable one to predict how the system will react towards outside influences. In order to make this precise prediction in any specific case, one must know the values of the several characteristic quantities which must in general be determined by special experiments. Our knowledge of these constants is still very incomplete, and there will be work for many generations of chemists before it is complete. But each one, being characteristic of a substance, can be applied to any case in which that substance as such takes part, and need not be determined separately for the numberless permutations which are possible. For we know at least a million different individual chemical substances, belonging to many thousands of different families, and this is but a small fraction of those that remain to be discovered and identified; and any one of these may, in principle, react with, or at least influence the behavior of, any other.

Great Influence on Development of Chemistry.

With the more general realization of the significance of Gibbs's work, about the beginning of the present century, chemistry took a new tack, and addressed itself to problems which in a sense had hardly been recognized as problems previously. In the 90's many chemists and physicists were almost of the opinion that the main outlines of physical science were known, and that little remained to do except to fill in more or less unimportant details; now we realize how grotesquely inadequate this picture was, and that what we know is an infinitesimal part of what remains to be known. This has again enhanced the romance of physical science, the sport of chemical work; for to penetrate into the unknown, to discover what is beyond the horizon, is the most attractive and enticing kind of amusement. In this change of attitude in chemistry Gibbs's work played a large part, leading as it did to the development of what has become known as physical chemistry; for his work—and particularly that small part of it known as the phase rule—proved to be an unfailing guide in the interpretation of experimental results. What the phase rule does in effect is to enable one to classify the multifarious, apparently altogether diverse, systems encountered experimentally into a small number of categories; those within any category behave in essence identically, whether simple or complex. This results in a great economy of thought and effort, as otherwise we would have to consider as a separate individual, each a law unto itself, every one of the large number of systems with which we have to deal practically.

In other words, we do not have to consider each chemical substance as an absolute individual which must be completely known before we can describe its response to changed conditions,—though this is not yet universally realized. Gibbs's work has provided a philosophy, a system of molecular ethics, a correlation of behavior of substances which simplifies our task of description in a way entirely comparable with the simplification effected by Newton in describing the paths of the heavenly bodies. It is altogether fundamental to progress in the science of chemistry, to the vision of the subject matter as a connected whole, with evolution from the simple to the complex, instead of as an unruly mob of isolated facts.

Many tributes to the value of Gibbs's work, both to the progress of science and to the development of industrial processes, could be cited, if space permitted, it will suffice to quote a few sentences from a paper written by Professor F. G. Donnan:

"Gibbs ranks with men like Newton, Lagrange, and Hamilton, who by the sheer force and power of their minds have produced those generalized statements of scientific law which mark epochs in the advance of exact knowledge . . . The work and inspiration of Gibbs have thus produced not only a great science, but also an equally great practice. There is, today, no great chemical or metallurgical industry which does not depend, for the development and control of a great part of its operations, on an understanding and application of thermodynamic chemistry and the geometrical theory of heterogeneous equilibria."

In short, he is regarded, by those most competent to assess his work, as on a par with men such as Newton or Maxwell; and his fame, in its scope and international character, is greater than that of any other Yale man, or of any American scientist. Indeed Lord Kelvin said here, a few years ago, that by the year 2000 Yale would be best known to the world for having produced Willard Gibbs.

In conclusion, may I apply to Gibbs his own very apt words, to be found in his obituary notices of Clausius (one of the founders of thermodynamics) and of his colleague and friend Hubert Anson Newton (Yale 1850; Professor of Mathematics 1855-1896):

"The constructive power thus exhibited, this ability to bring order out of confusion, this breadth of view which could apprehend one truth without losing sight of another, this nice discrimination to separate truth from error,—these are qualities which place the possessor in the first rank of scientific men . . . But such work as that of Clausius is not measured by counting titles or pages. His true monument lies not in the shelves of libraries, but in the thoughts of men, and in the history of more than one science."

"But these papers show more than the type of mind of the author; they give no uncertain testimony concerning the character of the man. In all these papers we see a love of honest work, an aversion to shams, a distrust of rash generalities and speculations based on uncertain premises. He was never anxious to add one more guess on doubtful matters in the hope of hitting the truth, or what might pass as such for a time, but was always willing to take infinite pains in the most careful test of every theory. To these qualities was joined a modesty which forbade the pushing of his own claims, and desired no reputation except the unsought tribute of competent judges."

May I express the hope that we may endeavor humbly to follow in his footsteps?

* Some of these may be found in another article which will appear in the SCIENTIFIC MONTHLY.

SEISMOGRAPH RECORDS EARTH VIBRATIONS

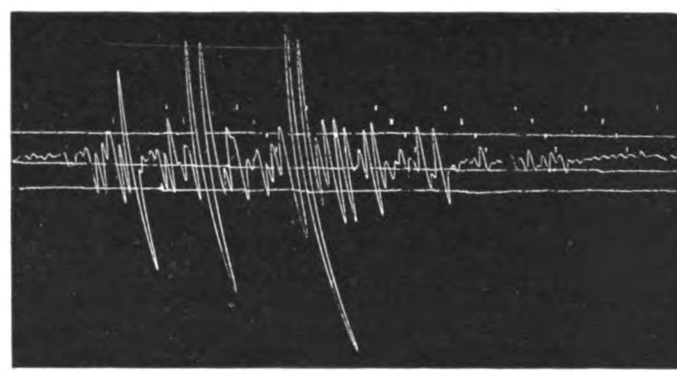
Three Distinct Kinds of Impulses Move Out from Locus of Shock—Time Interval Between Types of Waves Shows Distance

By PROFESSOR CHESTER R. LONGWELL

THE seismograph in Peabody Museum is a receiving station, to which come messages from Italy and the Grecian Isles, from Central America and Chile, from the Aleutians, the floor of the Pacific, and other remote parts of the earth. These messages are transmitted through the solid body of the earth in a definite, rhythmic code. We may compare the earth to a heavy bell, which gives forth sound as a result of vibration set up in the elastic metal by a sharp blow. For an appreciable time after perceptible sound has ceased, a slight trembling still can be felt in the bell. Similarly the earth responds to a blow by a rhythmic quiver that spreads rapidly in all directions from the point of impact. Commonly this vibration also gives forth sound, the terrifying rumble that accompanies many earthquakes. A violent shock makes the whole earth tremble, vigorously in the vicinity of the origin and with decreasing amplitude at more distant points. Hundreds or thousands of miles from the source the dying impulse, imperceptible to our senses, may be recorded faithfully by a delicate seismograph mounted on bedrock.

What can strike a blow sufficiently hard to shake the earth? Heavy volcanic explosions give rise to earthquakes, but a far more common cause is the abrupt snapping of the rocky crust under enormous strain. Movements on such breaks, known to geologists as *faults*, occur at frequent intervals in many parts of the earth. A long fracture, known as the San Andreas Rift, passes near the city of San Francisco. In 1906 a sudden slip offset roads, fences, and other features extending across this fault, with a maximum displacement of more than 20 feet. A vast amount of energy was released by the abrupt movement.

Three distinct kinds of impulses move outward from the locus of such a shock; two kinds penetrating into the earth, and the third traveling around the circumference. One of the through-waves, called the *primary* or *longitudinal* wave, travels with a velocity of several miles a second. Arriving at the position of a distant seismograph, it produces the first preliminary tremor, making a slight vibration on the record. The other through-wave, called the *secondary* or *transverse* wave, moves at a distinctly slower rate, and reaches the seismograph later than the primary, to set up the second preliminary tremor. The third impulse, traversing the longer route along the curvature of the earth, is the last to reach the station. This wave is the most vigorous of the three, and sets the arm of the seismograph swinging widely. After these *long* waves are past the recording needle is kept in motion for some time by a succession of complex waves.



Part of record made on the Yale seismograph by an earthquake 100 miles off the California coast, November 4, 1927. The preliminary tremors, which tell the distance of the shock from New Haven, are not shown. Actual vibration in the bedrock is magnified a hundredfold in the record.

The figure above illustrates in part a typical record of a distant shock. It represents the end of the second preliminary tremor (at left), the long waves (wide part of curve), and part of the later phases. The two preliminary tremors do not make a spectacular part of the record, but they are very important, as the time interval between receipt of the two impulses gives an accurate measure of the distance they have traversed. In this record the interval is about 360 seconds, corresponding to a distance of approximately 2,600 miles. By determining the distance from three separate stations, and drawing a circle about each station with the proper distance as a radius, a common point of intersection is found giving the exact location of the shock.

Other parts of the record have great scientific value. Persistent study of these records is furnishing a growing store of information about the earth's interior.

Among the contributors to the March issue of THE YALE SCIENTIFIC MAGAZINE will be Harry A. Curtis, professor of Chemical Engineering, who writes on "Progress in Knowledge of Coal and Its Better Utilization." Professor Curtis has devoted considerable study to the question of fuels.

Research Advances Physical Knowledge

Many Investigations Being Carried On at Sloane Laboratory in Effort to Solve Various Problems of Advanced Study

THIS year, as usual, the Sloane Physics Laboratory is the scene of much activity in research. Since these more advanced studies are carried on in parts of the building not usually seen by undergraduates and visiting alumni and often at times when the outside doors are locked, it seems only reasonable to review briefly what is going on and how time and money are being spent for the advancement of physical knowledge as distinguished from its dissemination by teaching. The easiest way to classify the investigations is to consider one by one the faculty members responsible for their progress.

Professor Zeleny has just completed his experiments upon the striated electric discharge in gases. At moderately low pressures and under certain ranges of applied voltage, the passage of the electric current through a gas in a long straight glass tube is rendered visible by the appearance at regular intervals along the tube of transverse layers of luminosity separated by nearly dark regions. These "striae" change their spacing as one varies the current through the tube or the potential drop across it. Though discharges of this kind have been studied at intervals by many previous investigators, the exact way in which the steady state is set up, and upon what its stability depends, is imperfectly understood. Professor Zeleny hopes that the drop in potential and distance between adjacent striae, which he has measured under carefully controlled conditions in various pure gases and mixtures of gases, will permit a decision between the diverse explanations hitherto offered for this complex state of affairs or will suggest a better explanation. Dr. Cooper has also been measuring potential differences in a gas carrying an electric current, but under wholly different circumstances from those in the experiments just mentioned. There is, in fact, a spontaneous potential gradient in the atmosphere of such a kind that a small positive current is almost always flowing down from inaccessible heights to the earth's surface. The atmosphere is such a good insulator that this current is hard to detect, although the potential drop per meter is usually in the neighborhood of 100 volts. The interesting thing is that the atmospheric potential gradient has sudden fluctuations of such magnitude that it may even change sign, and these changes, if enough of them can be correlated with changes in local, terrestrial, or solar conditions, should give a clue as to the origin of the potential gradient itself, which is one of the greatest mysteries of cosmical physics.

Another almost cosmical problem has been attacked by Dr. Adams and has now, as we might express it, "graduated" from the laboratory. The local broadcasting station, WDRC, found its reception interfered with by a distant station assigned to the same frequency band. The trouble was that the two frequencies actually used would usually differ by a frequency within the audible range, and this beat-note frequency would then be heard as a humming or whistling, running up and down as the frequency difference varied. It was clear that if the frequency difference could be kept sub-audible the trouble would cease, but this required closer frequency control than is customary or easy to attain. What Dr. Adams has done is to show, with the assistance of Mr. Doolittle, manager of WDRC, that sufficiently close thermostatic control of two tuned crystals, one in each station, is feasible. The Federal Radio Commission issued a brief report on these experiments early in December, which, with some imaginative embroidery, appeared in the newspapers. Larger scale experiments are now in progress at the interfering stations themselves.

In theoretical physics the productivity of the department during the year has been largely in the preparation of manuscripts for publication. Professor Page is just sending to press a book based on a thoroughly tested lecture course covering the whole subject. Dr. Lindsay, as joint author with Professor G. W. Stewart of the Iowa State University, is getting out an advanced textbook on sound, which will appear during the current year. Dr. Waterman is spending his leave of absence in study with Professor O. W. Richardson of King's College, London, their subject-matter being the conduction of electricity through metals.

Professor McKeehan is continuing, during his first year at Yale, work on what may loosely be called the "shape" of metal atoms. Because metal atoms, or some of them, are not like spheres all the atoms in a piece of metal can be made to take up special positions by specially applied forces, whether these forces are mechanical, magnetic, or of some other sort. The specialization is disclosed by the fact that various measurable properties differ when measurements are made along or across the direction of the applied force. Thus, for example, the measurable length of an iron wire, its electrical conductivity, its thermal conductivity, its elastic modulus all change when a magnetic force is applied along its axis. The close examination of such relations should give new information regarding the physical interaction of adjacent atoms in solids about which very little is yet known.

The particular "effect" Professor McKeehan is now studying is the change in electrical conductivity due to elastic pull in fine wires. Some of the graduate students under his direction are working on related problems, such as the rate at which energy is dissipated when magnetization changes as slowly as possible, how iron crystals approach magnetic saturation under strong magnetic forces, and the way in which optical absorption in a silver reflector varies when the regular arrangement of its surface atoms is disturbed by mechanical means. Another possible source of information about atoms in solids is found in studying their arrangement by X-ray methods. Dr. Kirkpatrick, who holds a Sterling Fellowship, is spending all his time on this line of attack, and several graduate students are beginning work on researches in which X-rays and crystals are of principal importance.

Professor Kovarik is continuing his study of the condensation of radio-active gases (radon and thoron) on cold surfaces, begun at Cambridge University two years ago. A first paper dealing with radon alone is now in press. The investigator finds that when the gas is present in such small quantity that it cannot completely cover the cooled part of the wall of the enclosure, even so thinly as one atom deep, the rate of evaporation from the surface at any low temperature is much less than it would be from a thick layer of frozen radon. Since radon is chemically inert this means that the forces holding it in place are quite different from the forces which hold atoms together in

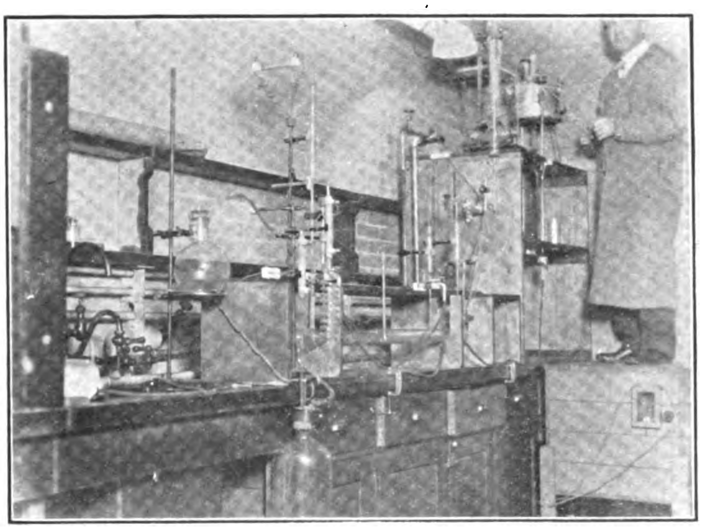
(Continued on page 38)

Yale Conducts Research on Tuberculosis

Chemical Investigation of Tubercle Bacillus Involves New and Special Technique in Bacterial Analysis—One Phase of Co-ordinated Attack on Disease.

By Prof. TREAT B. JOHNSON

THE chemical research work on tuberculosis now being carried on in the Sterling Chemistry Laboratory represents one phase of an extensive and co-operative investigation of this disease which is being supported by a special grant from the National Tuberculosis Association. The major program of research is organized and conducted under the auspices and counsel of a special Research Committee appointed by the National Tuberculosis Association. Yale's part in this co-operative research program is confined to the study of a number of fundamental chemical problems dealing with the constitution of the bacterial cell—*tubercle bacillus*—which is the cause of the disease. The chemical investigation of this bacteria is in reality a *pioneer undertaking* in a special field of experimental science, namely: "*Chemical Bacteriology*," and is more than a mere application of the technique of organic chemistry to the study of a complicated cellular organism. It is an endeavor to reveal some of the fundamental chemical changes functioning in the life of the cell, and if possible to separate from the cell the organic combinations which possibly characterize the biological activity of the respective bacterium.



A sectional unit in the Sterling Chemistry Laboratory being utilized by Dr. Moyer, National Research Council Fellow, for his research on the Sulphur Metabolism of Bacteria.

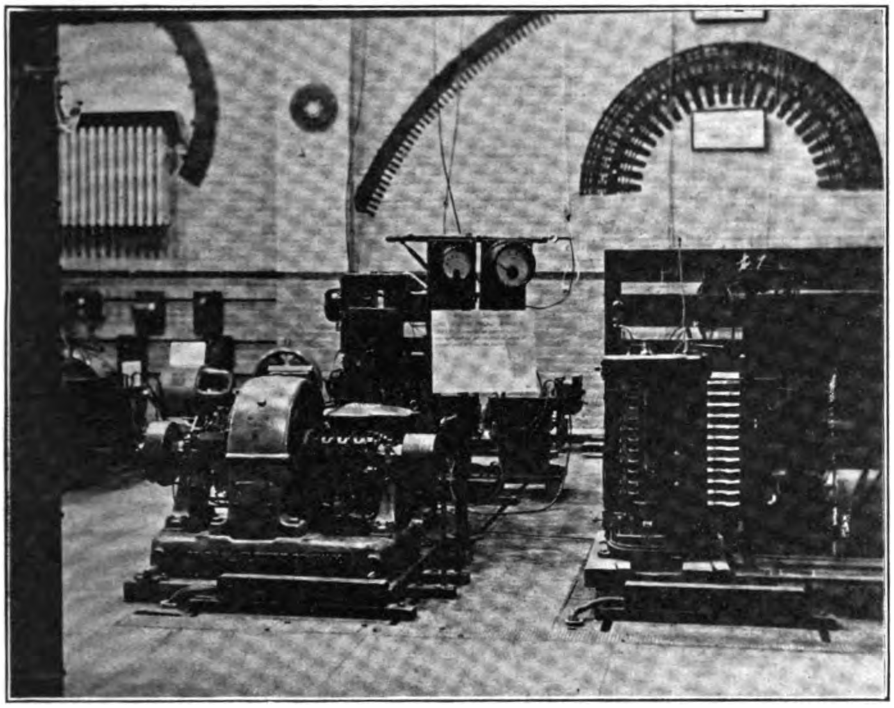
In the Sterling Chemistry Laboratory is now being operated a key or central chemistry research unit which is co-ordinated with several groups of workers in different institutions fully equipped to conduct a series of biological researches on tuberculosis. The latter are dependent for their source of experimental material on the chemical productions of the Yale chemistry unit. In other words, there is being developed here a *new and special technique of bacterial analysis* which should lead not only to a better understanding of the constitution of tubercle bacilli and bacteria in general, but will also make available for biological investigators and clinicians in tuberculosis sanatoriums and research institutions, cell fractions for specific animal experiments hitherto impossible to undertake. In fact, several of the biological problems now being studied could never have been incorporated into our present research program if the study of the chemistry of tubercle bacillus had not first been inaugurated. The newer problems dealing with the phenomena of immunity, of symbiosis, synthesis in the cell and cell assimilation, toxine and antitoxine formation, germicidal action and anesthesia, are dependent for their correct interpretation on a more exact knowledge of the chemistry of the life processes of the living cells.

This large research undertaking, inaugurated and supported by the National Tuberculosis Association, is an excellent example or illustration of the practicability of the present-day plan of carrying on research in related fields of science. It is impossible for an investigator qualified to operate in a single field of science to consider all the different phases of a biological research problem. The results obtained singly through his personal investigation do not disclose the necessary facts that are called for today, in order to present a final solution of a well-organized research program. It is now realized that this can be accomplished only by a joint and co-ordinated attack by a group of investigators trained in their respective fields of science. The success of such a research undertaking depends on a proper co-ordination of the activities of the group of researchers involved, on a mutual interest and sympathy between the different workers and a loyalty and unity of interest which binds the research organization together as a co-operative working unit.

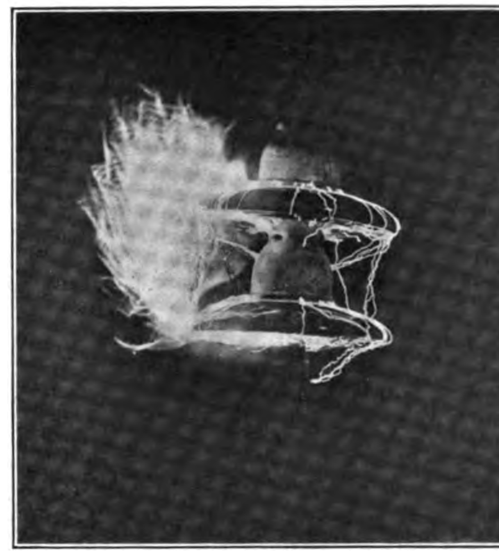
There is no doubt that this intensive research undertaking will have a great influence on the development and progress of tuberculosis medication. The era of hit-and-miss treatment, and the exploitations of quackery are gradually passing, and we are reaching today a stage where rational endeavors are being inaugurated; and chemistry is playing a very fundamental part in these new developments. As these fundamental research studies on tuberculosis approach solution we can confidently predict a much clearer knowledge of the chemistry of this disease and as a result, a much surer and saner basis of treatment than has ever been practiced before. The organic chemist and biochemist are doing pioneer work in a field which will do much to pave the way for further important biological researches into the deeper problems of specific immunity, and bacterial diseases.

The members of the tuberculosis research unit who are engaged in this chemical investigation in co-operation with the writer are Dr. R. J. Anderson, Professor of Chemistry; Dr. Robert D. Coghill, Instructor in Organic Chemistry, and Dr. Alice G. Renfrew, National Tuberculosis Association Research Fellow.

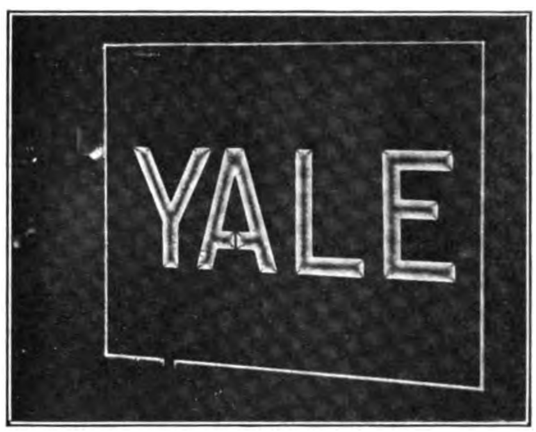
Professor Herbert L. Seward, '06 S., will contribute an article on Modern Marine Engineering to appear in the March issue of THE YALE SCIENTIFIC MAGAZINE. Professor Seward in addition to his duties as associate professor of mechanical engineering also serves as a member of the Fuel Conservation Committee of the U. S. Shipping Board. Being in constant touch with all improvements in Marine Engineering, he is well qualified to handle his subject.



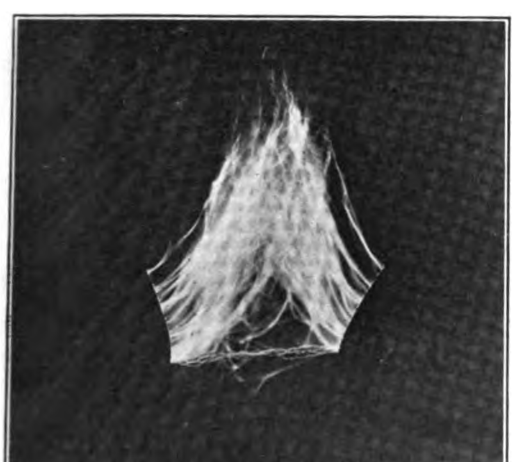
ABOVE.—*Model automatic converter substation set up in Dunham Laboratory for Student Electrical Exhibition of December 9 and 10. By a series of relays and contactors such a substation is able to take up voltage drop at a remote point in an extensive system without the services of an operator and with only occasional inspection.*



ABOVE.—*Two typical suspension insulator units being tested for corona and flash-over. The illustration shows flash-over at approximately 130,000 volts A. C. or 430 per cent overload for this particular insulator.*

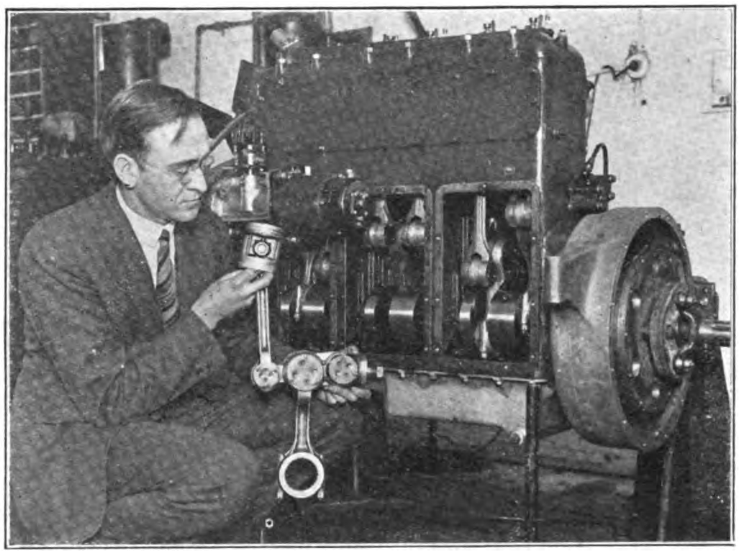


LEFT.—*Illuminated sign caused by corona, or blue-violet light resulting from partial breakdown of molecules of air surrounding a conductor. The effect shown was produced by 300,000 volts A. C. at 25,000 cycles per second passing through strips of tin foil on opposite sides of a very thin sheet of glass.*



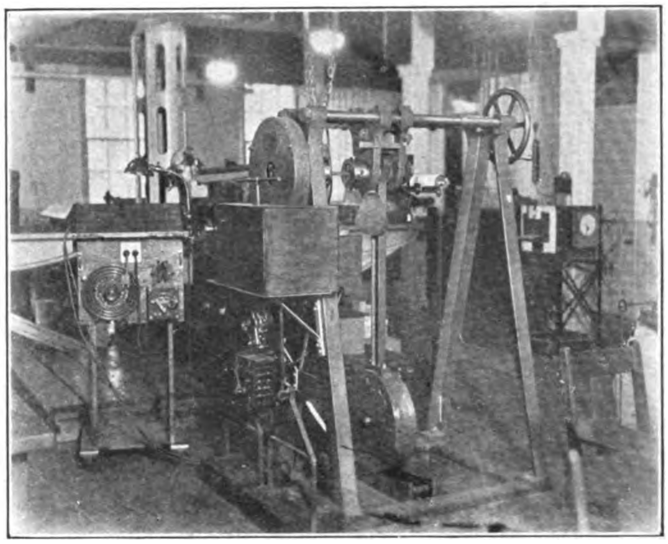
ABOVE.—*Photograph of a horn gap which acts as a voltage safety valve in an electrical system through horns placed in a ground wire from the line which diverge with the increasing size of the arc.*

RIGHT.—*General View of the Exhibition.*

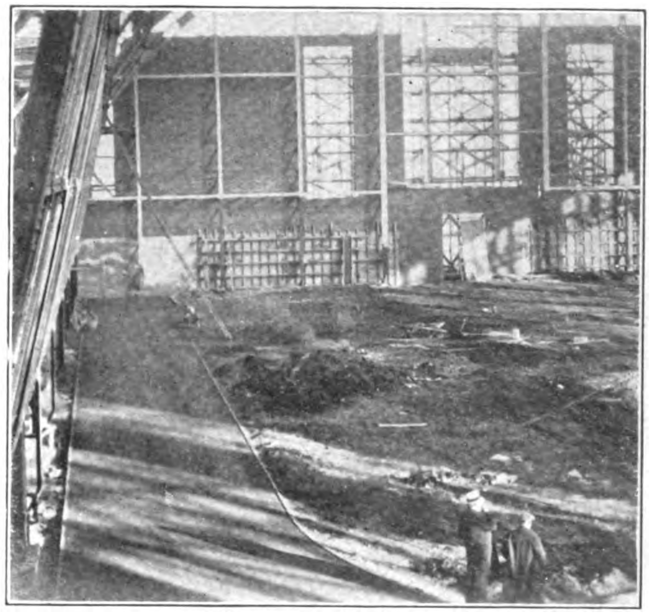


(Photo by Underwood)

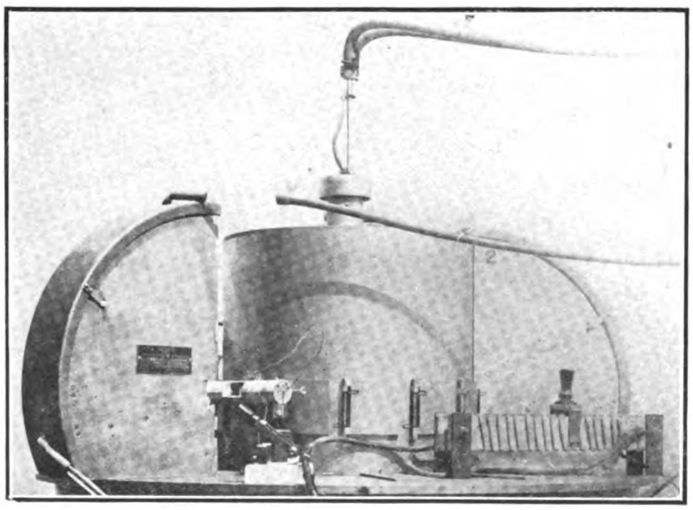
ABOVE.—*The Powell-Lever-Motor, developed by the A. L. Powell Co., which is hailed as a most significant contribution to automotive progress. The Powell-Lever-Motor utilizes a new principle consisting of a lever interposed between the piston and the crankshaft, which permits a longer piston stroke and is claimed to insure quicker and more complete combustion, less wear, greater mileage per gallon of fuel, superior acceleration, total absence of carbon, and immediate accessibility of all parts. Photo shows V. J. Swanson, engineer, looking over the motor.*



ABOVE.—*Olsen Pendulum Tortion Machine with a maximum capacity of ten thousand inch pounds. Used to determine the tortion strength of samples of steel, especially steel rods. This machine has been added to the mechanics laboratory just recently.* (Photo by News Pictorial)

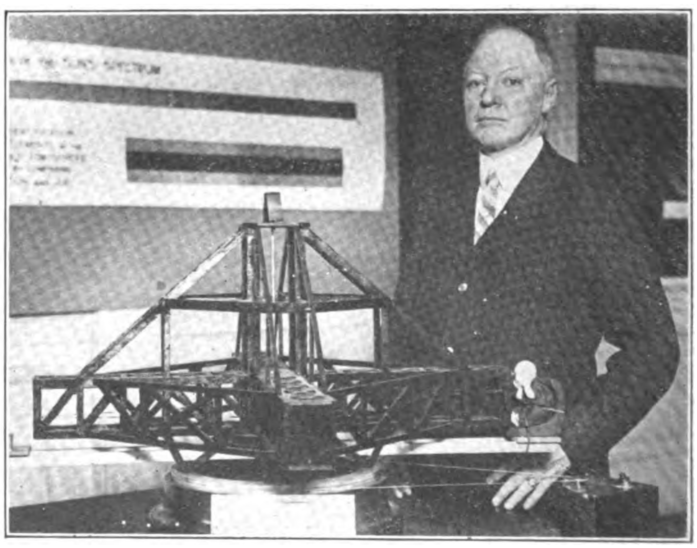


ABOVE.—*Interior of the new Yale baseball cage now under construction.* (Photo by News Pictorial)



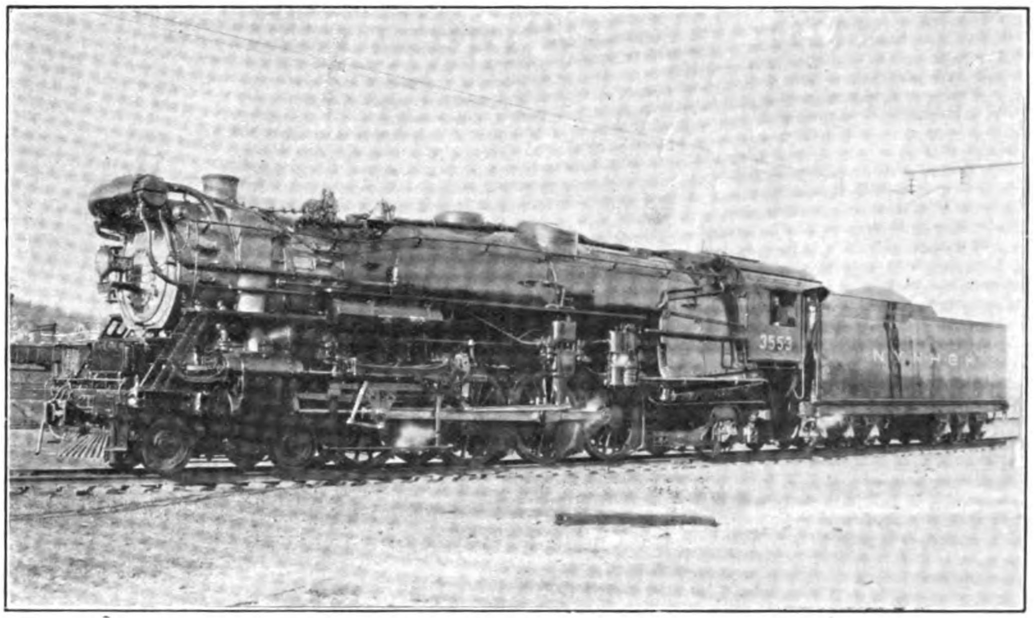
ABOVE.—*X-Ray Diffraction Apparatus used at the Hammond Metallurgical Laboratory for the study of metals at high temperatures.*

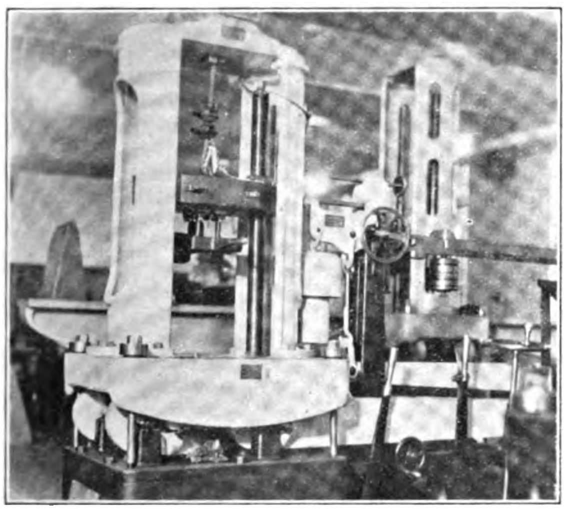
RIGHT.—*Dr. Frank F. Bunker, editor of the Carnegie Institution, Washington, with a model illustrating the famous Michelson-Morley ether-drift experiment, now being repeated by Professor Michelson at Pasadena, California.*



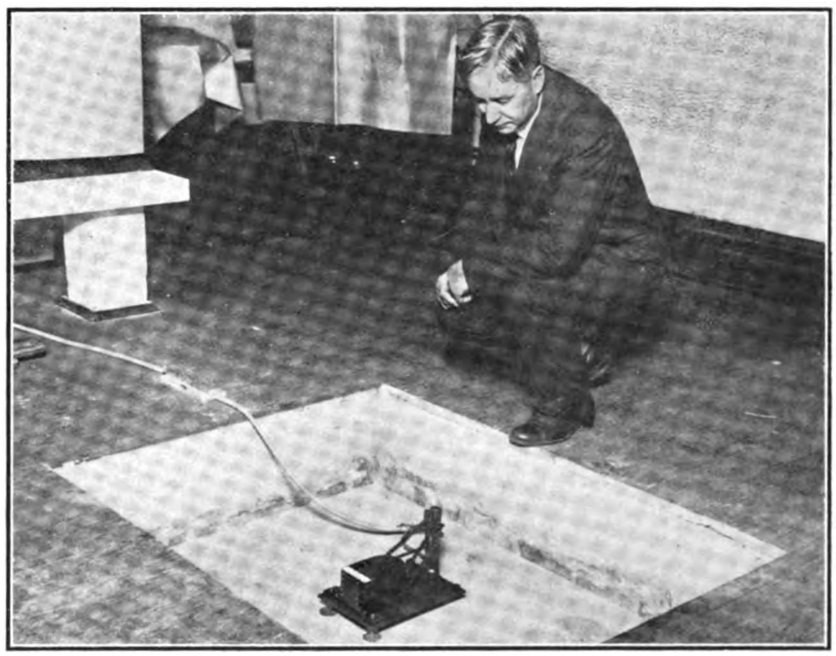
(Photo by Underwood)

RIGHT.—*New three cylinder high speed freight locomotive, first of ten "New Haven" type engines to be supplied to N. Y., N. H. and H. R. R. by the American Locomotive Company. Features of the equipment are a Bean Smokebox, Automatic Stokers, Multiple Throttle, and McClellon Boilers designed for a pressure of 265 pounds.*



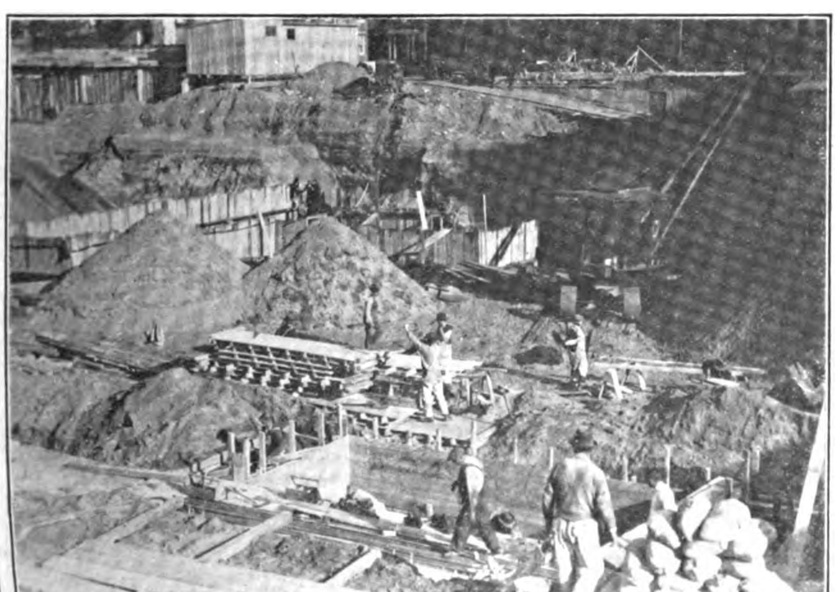


ABOVE.—*A machine for determining tensile strength in the Sheffield Laboratory of Engineering Mechanics. The specimen undergoing test is a piece of three-quarter inch wire rope.*



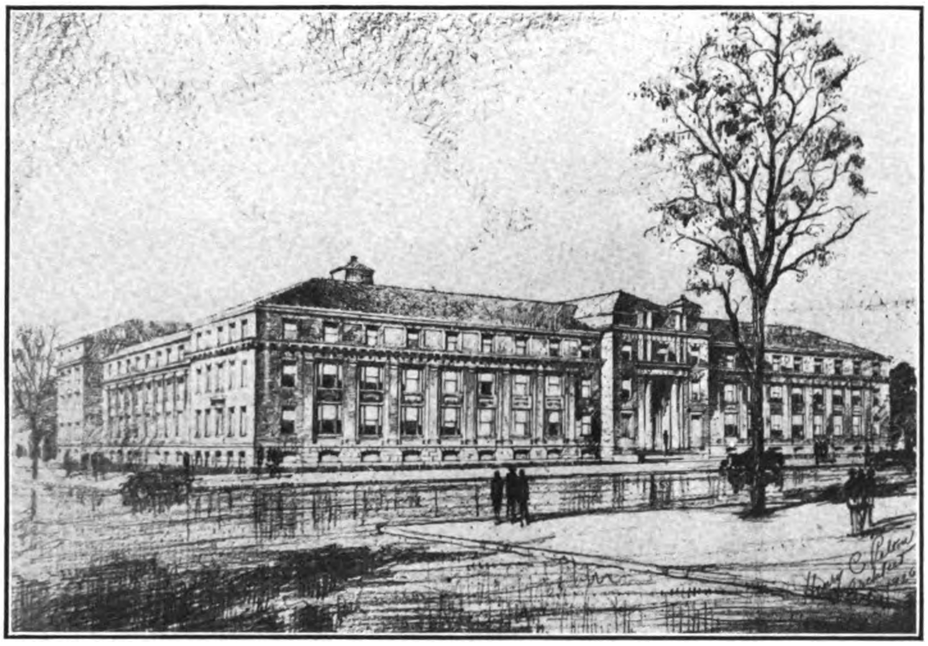
(Photo by Underwood)

ABOVE.—*In co-operation with the Carnegie Institute and the Coast and Geodetic Survey, Dr. Frank Wenner of the Bureau of Standards has developed a new and greatly improved seismograph. Dr. Wenner's device is very small, about the size of a radio A battery as compared with other massive machines weighing hundreds of pounds. It consists of a coil of wire suspended like a plumb bob between the poles of a permanent magnet. Earth vibrations cause the coil to move between the poles of the magnet, thus generating a minute current of electricity which is magnified about a thousand times and recorded photographically on a moving strip of paper. Photo shows Dr. Wenner and the new seismograph.*



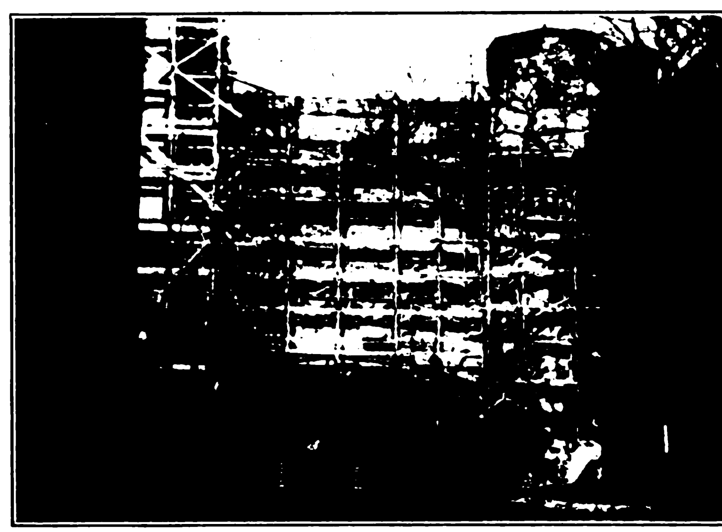
LEFT.—*Photo shows the progress of the work on the foundations for the new Yale Library.*

(Photo by News Pictorial)



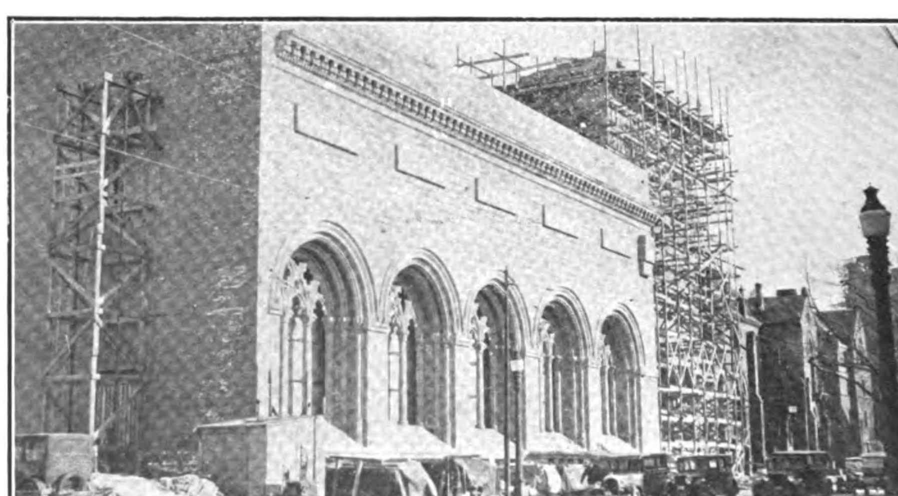
LEFT.—*Architect's drawing of the new addition to the Anthony N. Brady Memorial Laboratory of the Medical School, which will cost $1,250,000.00. The addition, which was started last June, will be ready for occupancy at the beginning of the next Academic year and will house facilities for research in Pathology and Bacteriology and the departments of Nursing, Obstetrics, and Gynecology.*

Henry C. Pelton, Architect.



RIGHT.—*The connecting link which joins the Yale Art School with its new Museum. The low, squat, castellated arch and heavy towers are the essence of the architecture of the period intermediate between Romanesque and Gothic.*

BELOW.—*Professor Samuel T. Record of the Forestry School examining a recent shipment of wood specimens from Africa.* (Photo by News Pictorial)



ABOVE.—*The new Yale Art Museum. A splendid example of rugged Romanesque architecture before it vaulted into the more aëry Gothic. Note the massive walls entirely of stone and the over-all simplicity.* (Photo by News Pictorial)

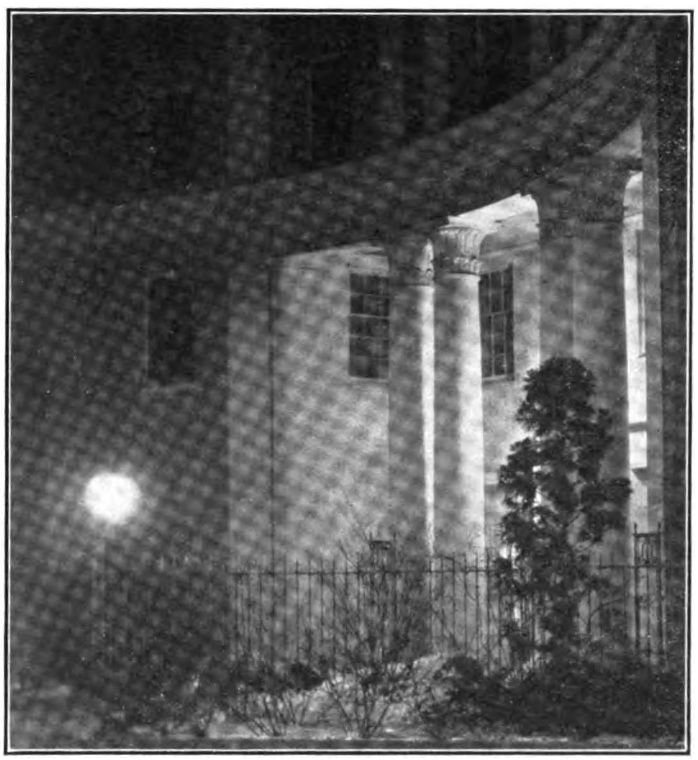
New Methods Used in Medical Education

Yale Medical School is a Pioneer in New Training in Which Students and Faculty are Working for Common Aim

By Prof. HAROLD S. BURR

What is the Meaning of Education?

WHY do men seek an education? It is a question easy to ask but difficult to answer. This is true chiefly perhaps because the answer lies in the realm of the imponderables that are difficult of definition and exact statement. Nevertheless, it is fairly safe to assume that where education is sought voluntarily its chief objective is self-development. Here again it is difficult to define the term "development" in objective terms because "development" connotes different things to different people. If we may be permitted to use a psychological term, self-development means that as a result of it the individual is better able to adjust himself to his environment. When one considers all that is implied in such a definition the complexity of the problems of education are at once apparent. In the last analysis adequate adjustment means a steady increase in the number of contacts which an individual can make with his environment, a more accurate understanding of those contacts, a better judgment based upon them and a more effective response to them. The most striking thing to be noted here is that in a very real sense such a process can not be taught the individual. He must train himself. The function then of an educational system can only be that of creation of opportunities and guidance in the pursuit of them.



Sterling Hall of Medicine.

American Education as Compared with European.

In this respect European educational systems are notably superior to our American. We have assumed that individuals can be taught adequate adjustment to their environment and the result has been the wild scramble for courses and credits and degrees as though the acquisition of them were an "open sesame" to a future life. Our whole university life is built around a galaxy of courses, of schedules, class room exercises, lectures, recitations and examinations that follow each other with bewildering rapidity. Is it any wonder that the modern university student in this country turns with avidity to extra-curriculum activities where he creates his own opportunities, makes his own adjustments and develops himself as an individual?

It is the tragedy of education that the intellectual capacities of the students are not aroused or developed. By far the majority of the courses which the undergraduate takes stultify what little interest may have appeared during his preliminary training. Monotonous routine and uninspired contacts discourage intellectual pursuits. And yet one striking thing is evident. American students for some unknown reason still retain a curious eagerness which is almost entirely lacking in their continental brothers. In Europe the student is unquestionably better trained. His stock of facts is very much greater. On the other hand, it may be questioned whether he is any more successful at using those facts. In Europe students study with masters in their fields, and are very apt to assume the role of hero worshippers with the result that schools of thought, perilously approaching cults, develop. The vigor and variety of American life and the fundamental eagerness of American students would almost certainly prevent the blind following of individuals, and the net result of exposing them to contacts with true intellectuals would be enormous.

Possibility of Improved Methods.

It is perfectly clear that if a little thought and time were spent on the curriculum of the undergraduate departments of the average American university, a program could be worked out which would mean no more work for the instructors and vastly more inspiration for the students. It is difficult to do this on a large scale, but individual units with smaller numbers can successfully make the necessary adjustments. There is no reason under heaven why the chief interest of the undergraduate should be focussed on athletics, extra curriculum activities, and the social life of the university. They are valuable and have their place, but assuredly they ought not to determine the composition of the entire picture. As a matter of fact, the remedy is relatively simple. The growing mind of the college student needs only to be exposed to the contagion of an interested mind. If this were made possible there would most certainly develop a wild scramble for fields of study and for contacts with inspired workers in those fields.

Pioneers in New Educational Policies.

These general remarks about a general university education apply with equal force to professional education, although here

the objective is somewhat more clearly defined and the field of endeavor somewhat more restricted. Yet as one looks at medical education in this country, one finds that it also is burdened with the scramble for courses. This is the more surprising when one considers the innovation at Johns Hopkins University in the 90's which was successful in substituting fields of study for courses. But educationalists like priests found cults based on tradition and battlemented with the high walls of precepts and rules. In the last century two men in this country had the vision to see the sterility of American educational systems and crusaded for new and better things. Eliot of Harvard and Gilman of Johns Hopkins did their utmost to change the tide. Whether or not they were successful is too early to be determined, but there are many indications to justify such a belief. The Yale School of Medicine is one of these justifications. Under the leadership of its Dean the school in the last seven years has been successful in inaugurating a changed attitude toward the objectives of medical education.

Different Aims in Studying Medicine.

It is quite clear that the majority of men entering medical school do so for one of three reasons. Undoubtedly a certain number of men enter medicine in the hope that they can exploit the knowledge they acquire in medical school for their own social or economic advantage. Many students seek the medical degree because of the opportunity that it will give them to serve the sick and needy of their day and generation. There is a third group, very clearly the smallest of them all, who enter the field of medicine in the hope that they can make their contribution, however small, to the science of medicine. The first group is unworthy of consideration and can be dismissed without further comment. The second group, possibly the largest of the three, deserves all the aid possible. There are many schools in the United States entirely competent and equipped to train men for that objective. The third group is nevertheless the most important because out of it grow the men who further the progress of the science, the men who steadily add to the body of information by means of which each and everyone of us profit. Obviously the training of the third group must needs include the training of the second group but must go beyond it.

The Purpose of Yale Medical School.

It is this idea that the Yale Medical School has sought to reach; to train men in the practice and theory of medical science. Members of the student body are given every opportunity to become frontiersmen on the border lines of knowledge. Students and faculty alike work together to steadily push those boundaries further afield. It is perhaps this last factor, that students and faculty are working together for a common aim, that helps to distinguish the school of medicine at Yale from other centers of medical education. The pursuit of knowledge can be and should be one of the most fascinating of human endeavors, and it is the shame of our American education that such an attitude is not fostered among the better minds of the student body. As indicated above, the only means to develop this fascination is contact with men who themselves are fascinated.

The mechanical factors devised to facilitate the accomplishment of this ideal are not of fundamental importance. Real success can only be accomplished through the personnel of the institution. Furthermore, the procedure in the Yale School of Medicine does not differ fundamentally from similar procedures elsewhere, notably at Harvard, and yet no one who visits the Yale School of Medicine can help but be impressed with the spirit of the place.

(*Continued on page 35*)

YALE TO EXCAVATE ANCIENT CITY

Archaeological Expedition Will Commence Work in Spring of Uncovering Dura, Buried Twenty-two Hundred Years

An archaeological expedition of Yale University, with the permission of the Syrian Government and in collaboration with the French Academy, is to excavate the ancient city of Dura, on the Euphrates, which for over twenty-two hundred years has been covered by the sand of the desert. Excavation work is expected to commence this spring. Professor Michael I. Rostovtzeff, Sterling Professor of Ancient History and Classical Archaeology at Yale, who conducted the negotiations with the French Academy, is to visit the scene when work is commenced, representing the University. The work of the Yale expedition is made possible through an appropriation from the General Education Board of New York.

In 1920, a detachment of British soldiers stationed on the Middle Euphrates at a place called Salihieh, informed Miss Gertrude Bell, the noted Orientalist, of the discovery of some beautiful frescoes in the ruins of what had been a fortified city. Miss Bell immediately informed Professor James Breasted, Director of the Oriental Institute at Chicago, who at once hurried to the place. When he arrived the soldiers were about to leave. Having only twenty-four hours in which to work, he photographed the frescoes and made colored copies of them, and made approximate plans of the ruins. Upon returning to Europe, Professor Breasted made a report of this discovery to the French Academy of Inscriptions. At that time the land in which the ruins were located was under the protectorate of France, and the French Academy, realizing the importance of the discovery, decided to excavate the place. Professor F. Cumont, who some years ago lectured at Yale, was sent to Dura for excavating work. He worked there with the help of soldiers of the French Foreign Legion, and the discoveries he made, according to Professor Rostovtzeff, were startling. Besides ruins of temples, fortifications, and elaborate graves, Professor Cumont discovered most interesting frescoes of a new type. He also found fine sculptures, scores of inscriptions of great importance, and about a dozen of Greek, Latin, and Aramaic parchments. Egypt has many papyri and parchments, but outside of Egypt, the discovery of documents written on parchment is very rare. Only one such discovery has been made before, and the Dura parchments were, in consequence, an extraordinary find.

Historical investigation of the place showed that it was an ancient Assyrian fortress named Dura, later replaced by a Macedonian military colony, Europos, at about 300 B. C.

Very little is known of the cities which were created by the efforts of Alexander the Great, and his successors, and Professor Rostovtzeff declares it is of great importance to know more about this. Dura, which received the name Europos from her Macedonian founder, is the first city of this type to be excavated. Later the city became Semitized, and still later was under the domination of the Parthians, the powerful rivals of the Romans. At the end of the Second Century after Christ, the city was incorporated into the Roman Empire with the great city of Palmyra. In the next century, the Romans left the city, and it became a part of the desert, as it is now. Professor Cumont and the Academy have excavated only a little portion of the city. Ho wmuch more information the ruins contain which have not been touched, and how many parchments still await the explorer is not known. The French Academy realized the importance of the excavations, but neither the Academy nor the Syrian Gov-

(*Continued on page 39*)

P·E·R·S·O·N·A·L·I·T·I·E·S

No. 3. *HOWARD WILCOX HAGGARD*

IN the oldest and shabbiest of our buildings, that once was a fair and stately private residence, in the room that once was the boudoir of Mrs. Sheffield, wife of the founder of the Scientific School, now dwells a pre-eminent personality who in the brief space of three years' contact with the undergraduate body has attained a place of high esteem in the hearts and minds of those who know him and hear him. That room has lost all traces of the feminine touch; its walls are dirty and bare; its windows are scarcely transparent, and behind a huge bench covered with a wild order of papers and books sits the subject of this sketch.

Dr. Haggard started life under the same handicap as did Will Hays, James Whitcomb Riley and other famous Hoosiers. None too soon did he leave his Indiana home to prepare for college at Exeter. At Exeter he was a remarkably poor student. His extra-curricular activities were hardly sufficient to justify his poor scholastic record, for chief among them was a try-out for the boxing team in which he committed the indiscretion of knocking out the pride of the school team. This incident brought him much ill-favor that he could not understand, until some time afterwards when he learned the difference between boxing and prize fighting.

In 1912 he matriculated at Yale, electing the pre-medical course in the Sheffield Scientific School. After two years in the Scientific School he entered the Medical School. This unusual course was made possible by the absence of the dean and because of his high scholastic record, quite different from his prep school standing. While still an undergraduate his literary abilities were recognized. He was elected to the Elizabethan Club, an honor seldom received by a student in the Scientific School. While in the Medical School he was elected to Sigma-Xi. During his senior year in the Medical School he married on an income of nothing a year. In June, 1917, he received his medical degree with the highest honors ever conferred by the Yale Medical School.

After graduating he entered the Army to conduct Chemical Warfare research. Within a year he was raised to the rank of Captain, with fifty men under his charge, though he didn't have sufficient military knowledge to save himself from occasional embarrassment. While experimenting with poisonous gas he was accidentally poisoned and was in very serious condition for some time, losing more than forty pounds during his illness.

After the war he completed his work as interne at Bellevue Hospital in New York; his experiences on the Bowery were as interesting as those of an interne can be. Because of his strong desire for research and the academic life, he abandoned the practice of medicine.

In 1919 he was appointed instructor in the Medical School under Professor Yandell Henderson, under whom he had served during the war. A few years later there was a general reorganization in the Medical School and for social, racial, or religious reasons these two physiologists found themselves unwelcome in that School. The outcasts found refuge in the open arms of the Sheffield Scientific School and formed the Department of Applied Physiology. For some years their efforts were devoted mainly to research, in which the work of these two men was inseparable.

In 1921 Dr. Haggard offered for the first time his course in Industrial Physiology. Eight students elected it the first year; they consisted of graduate students and faculty members, the course being offered in the graduate school. During the following two years the number of students doubled each year. In 1924 his course was opened to the undergraduates for the first time, and it was chosen by more than sixty students. His classes have continued to increase in number so that he now has more than three hundred students, and from the present outlook the growth will be limited only by the size of the student body.

Attendance at his lectures is remarkable. It sometimes reaches as much as one hundred fifty per cent of the number electing the course when he speaks on his most popular subjects. However, some of his lectures are less successful. There have rarely been cases in which the attendance dropped during his lecture. No course has ever experienced such a phenomenal growth. Dr. Haggard has already taken his place among the foremost lecturers of Yale, and his course is among the most prominent in both the College and the Scientific School. Perhaps Sheff would not need to apologize for its lack of Harknesses if it had more Haggards. His course is an elective for all except Industrial Engineering students, for whom it is required, and they comprise less than twenty per cent of his class. In the past three years he has been twice voted by both Academic and Sheff undergraduates as the most inspiring professor, and his course has been voted the most

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Geology

Professor Charles H. Warren, who had extended mineralogical researches carried on under his direction by Messrs. Putnam, Selchow, and Roberts, has been getting some of the material into shape, and it is appearing in a series of articles in the *American Journal of Science*.

Emeritus Professor Charles Schuchert has left Peabody Museum for the South and Southwest in a study of stratigraphic geology.

Professors Longwell, Bateman, Knopf, Dunbar, Agar, and Flint are at present engaged in a revision of the *Textbook of Geology* by the late L. V. Pirsson.

Professors Bateman, Longwell, Agar, Dunbar, and Flint attended the annual meeting of the Geological Society of America at Cleveland, Ohio, during the Christmas recess.

Civil Engineering

Under the auspices of the Student Branch of the American Society of Civil Engineers, the following three lectures have been held this fall. Dr. Howard W. Haggard spoke October 3rd on "What a Man Can Do;" Dr. W. E. Britton, State Entomologist, November 13th, on "Mosquito Elimination," and Mr. Edward Wegman, consulting engineer of New York City, December 12th, on "Ancient and Modern Waterworks, from Rome, Italy, to Greater New York." The latter was an evening lecture, attended by many from outside the University.

Professor Suttie has recently completed, for the State Geological and Natural History Survey, a study of the water resources of Connecticut. The results of the study will be published in the near future. Professor Suttie has been appointed a member of the Committee on Mosquito Elimination of the New Haven Chamber of Commerce.

Professor Kirby spoke last fall before the New Haven Kiwanis Club on "Motor Vehicle Accident Statistics." He is continuing his annual studies of Connecticut accidents in co-operation with the State Motor Vehicle Department.

The civil engineering departmental library has been considerably enlarged this year by the purchase of works of reference in many fields.

Professor C. T. Bishop's latest book, "Problems in Structural Design," was published recently by John Wiley and Sons.

Among the recent trips of inspection conducted by members of the departmental faculty have been the following. Professor Bishop took his class in Structural Engineering to the Berlin Bridge Company's plant at East Berlin, and Mr. Allen, with his class in Architectural Engineering, visited the works of the Porcupine Company in Bridgeport.

Physics

Professor Leigh Page has finished the manuscripts for a new book on Theoretical Physics.

Dr. F. L. Cooper is in the midst of a long series of observations of the electrical condition of the atmosphere and is finding an important relation of this condition with the rotation of the sun.

A new thirteen-inch Pratt & Whitney Precision Lathe has been added to the equipment of the shop. A Universal Goniometer for the study of crystal structure by means of X-rays has just been completed, and a new Air Liquefier is in process of construction.

Professor John Zeleny has concluded an experimental research on the energy relation in striated electrical discharges.

A book on New Methods in Geometrical Optics by Professor Charles S. Hastings has recently appeared from the press.

Messrs. Lawrence, Beams and Garman are constructing for some research work a rotating mirror with which it is hoped to get a million revolutions per minute.

Mathematics

Professors Give Invitation Lectures.

At the December meeting of the American Mathematical Society, held at Nashville in conjunction with the annual meeting of the American Association for the Advancement of Science, two of the invitation lectures were delivered by members of the Department of Mathematics. Professor E. W. Brown gave the Josiah Willard Gibbs Lecture. This lecture, sponsored by the two societies mentioned above, is given in honor of the late Professor Gibbs, Yale's most famous scientist. The title of Professor Brown's lecture was "Resonance in the Solar System." The second invitation lecture was given by Professor James Pierpont. His

(*Continued on page 36*)

Electrical Engineering

Traffic Control System.

Mr. H. A .Haugh, Jr., instructor in this department, has devised and developed a unique traffic control system. It is a method of operating the lamps which are placed at street intersections. These signal lamps usually operate on a definite time schedule regardless of the traffic conditions. By the new method the right of way is given immediately to an approaching vehicle when there is no cross traffic. The device may be adjusted to meet various traffic conditions such as the principal streets of a city or of a main highway with branch roads of secondary importance. The device has been inspected by various public traffic officials and has met with favor.

Graduate Lectures.

The following persons have delivered Graduate Lectures in the Department of Electrical Engineering:

(*Continued on page 36*)

Chemistry

About a dozen men in Physical Chemistry are engaged in research problems, the results of which will be published later.

Professor R. J. Anderson is co-operating with Professor T. B. Johnson and the National Tuberculosis Association in an extensive research on tuberculosis. Findings have been made which have revealed a close relationship between the life activity of the tubercle cell and its ability to metabolize fats.

Dr. Alice G. Renfrew is conducting a research in the Sterling Laboratory on the chemistry of sugars, functioning in the normal growth of the tubercle bacilli. This work is being carried on in conjunction with the United States Hygienic Laboratory in Washington.

Dr. Blythe Eagles has returned to the Sterling Laboratory after a leave of six weeks, which was spent in the laboratory of the Bureau of Dairying, United States Department of Agriculture, in an investigation of gluta thione, a sulphur constituent found in animal blood. This research will be continued this coming term in New Haven.

Professor A. J. Hill attended the National Organic Chemistry Symposium at Columbus, Ohio, December 29th to 31st,

(*Continued on page 36*)

Mechanical Engineering

Professor W. J. Wohlenberg presided at the meeting of the Fuels Division of the American Society of Mechanical Engineers at the Annual Meeting in December.

Mr. Maurice Olley, Chief Engineer of the Rolls Royce Company of America, addressed the student seminar recently on "What Constitutes an Engineer?"

Professor L. C. Lichty is continuing his experiments with a new optical indicator for measurement of pressures in the cylinder of an internal combustion engine.

Professor E. H. Lockwood contributed an article in the Research Department of the Society of Automotive Engineers on "Exhaust Gas Analysis Calculations," S. A. E. Journal, November, 1927. Studies are being continued at the Mason Laboratory on the exhaust products and the light they may shed on the combustion process.

Do the railroads want college graduates? What opportunities do the railroads offer compared with the manufacturing industries? These and similar questions were discussed at a joint conference in New York on December 6, 1927. Representatives were present from the American Society of Mechanical Engineers, Railroad Division, Executive Committee and Sub-Committee on Professional Service, the American Railway Engineering Association Committee on Relations of Colleges and Railroads, and a similar committee of the Society for the Promotion of Engineering Education. Professor S. W. Dudley, Chairman of the S. P. E. E. committee, presided.

Professor H. L. Seward participated in the trial runs of the U. S. S. "California," held on January 7, 1928, out of Newport News. The "California" is the largest electrically driven passenger ship yet built. The trials were very successful in every particular.

Physiology

Professor Henderson and Professor Haggard have four papers in the *American ournal of Physiology;* these papers deal with their researches on the measurement of the rate at which the heart pumps blood, and report determinations made on fifty Yale students.

The textbook for Professor Haggard's course in physiology has been published (Harper & Brothers) under the title "The Science of Health and Disease." A trade edition is being published under the title "What You Should Know About Health and Disease."

The first installment of a serial story by Professor Haggard appears in the January issue of *Hygea.* This story is for children and bears the title "Junior and Mr. Germ."

Biology

Dr. Woodruff is continuing his work on the cytology of the Protozoa.

Dr. Kirby recently published an article on the parasites of ants.

Dr. Buchanan is continuing his studies of the regeneration of the Flatworm.

Dr. Steele is working on the genetics of pigeons.

Dr. Baitsell is continuing work for the National Tuberculosis Association.

Dr. Nicholas is working on the nerve system of rat embryos.

Dr. Petrunkevitch has recently completed a monograph on *The Spiders of Porto Rico.*

Astronomy

The American Astronomical Society met at the William L. Harkness Hall on December 29th and 30th. Professor Comstock, of Wisconsin, President of the Society, and Professor Schlesinger, of Yale, former president of the Society, presided over the sessions. Papers were presented by Professor Brown, Dr. Schilt, and Mr. Slavenas, all of the Yale Observatory Staff. Nearly one hundred members were in attendance, a record number for the Society.

This meeting was followed by a session of the American section of the International Astronomical Union on December 31st. This session was in preparation for the meeting of the Union itself to be held next July in Leiden, Holland.

Botany

Professor George E. Nichols attended the Nashville meetings of the Botanical Society of America, of which he is treasurer, during the Christmas recess.

Dr. Carl G. Deuber presented a paper before the Botanical Society on *Mineral Nutrition and Chlorophyll Development in Seedlings.*

Mr. Rush P. Marshall is investigating wound dressings for shade trees, in collaboration with the United States Department of Agriculture.

(*Continued on page 36*)

Forestry

Dean Graves represented the University at the recent conference of Forest Schools at Berkeley, California. He also spoke at the meeting of the Society of American Foresters in San Francisco, when some two hundred and fifty foresters, chiefly from the West, were in attendance. Over thirty graduates of the Yale Forest School were present.

Professor Toumey has recently completed a manuscript on the testing of coniferous tree seeds at the School of Forestry from 1906 to 1926.

Professor Toumey is now revising the manuscript of "Foundations of Silviculture Upon an Ecological Basis." The book will be published by John Wylie & Sons in the spring.

Professor R. C. Bryant has been engaged for some months in the preparation of a plan of management for forest holdings in southeastern Arkansas owned by the Crossett Lumber Company, for whom he is consulting forester. The purpose of the management plan is to devise ways and means by which an adequate future supply of raw wood material may be provided in order that Crossett may continue as a wood manufacturing center for an indefinite period.

Professor Samuel J. Record estimates that there are 3,000 different kinds of woods in the world (counting all oaks as one kind, all maples as another, and so on), belonging to 160 plant families. About two-fifths of the different kinds and 150 of the families are represented

(*Continued on page 36*)

Mining and Metallurgy

The X-ray Diffraction Apparatus at the Hammond Metallurgical Laboratory is being modified by the General Electric Co. to include several improvements made since the original equipment was designed.

The mechanical equipment of the ore-dressing laboratory has been improved by the addition of a Dorr Classifier, a small rod-mill and a drag classifier. These additions make possible the grinding in closed circuit of both large and small amounts of material. Also a Gayco air-separator and a modern vibrating-screen have been installed. For gravity concentration of ores a new shaking table has been set up, and the Harz jig has been reconstructed. The department has been co-operating with the Dorr Company of New York in providing facilities to conduct tests on the classification and concentration of various ores.

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

C. J. LaRoche, '17 S., *Editor.*
G. S. Moore, '27 S., *Assistant Editor.*

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H. S. Pickands, '97 S.	C. J. LaRoche, '17 S.	E. M. T. Ryder, '96 S.

Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

This department is prepared by the Yale Engineering Association. The Editors of the Yale Scientific Magazine are not responsible for its contents.

WITH a confidence that the graduates of the Sheffield Scientific School have been brought closer to their Alma Mater through the activities of the Yale Engineering Association during the past year and especially through the interest created by THE YALE SCIENTIFIC MAGAZINE, the Association takes up its work of 1928 with renewed vigor.

The efforts of your officers are centered on their intensive program to raise the membership of the Association to 2,500 in the next few months. Five hundred prospective members were sent sample copies of the last issue of THE YALE SCIENTIFIC MAGAZINE and they are being followed up by the "Every member get a member" campaign now under way.

At the same time the committees are hard at work, and it is expected that there may be some important announcements made in the March issue. One of the interesting events of the Association's activities is the annual joint meeting of the Harvard Engineering Society and the Princeton Engineering Association with the Yale Engineering Association, which has been arranged for the evening of January 20 at the Yale Club at 8 P. M. This year's meeting is of unusual interest because of the selection of aviation as the subject for discussion. The three men in our government who are responsible for the development of aviation for commerce, the navy and the army are to be present, the three assistant secretaries who have been assigned to aviation. They are the Hon. F. Trubee Davison, assistant secretary of War for Aviation; the Hon. Edward P. Warner, Assistant Secretary of the Navy for Aviation, and the Hon. William P. MacCracken, Assistant Secretary of Commerce for Aviation. In addition there will be a large group of prominent Army, Navy and Civilian aviators, who will talk on different aspects of aviation. Moving pictures of official government planes will be shown in connection with the talks.

The committee which is responsible for the excellent program, which is sure to arouse nation-wide interest when the speeches are given to the public, are T. R. Kendall of Harvard, C. F. Ivins of Princeton, and W. E. Dowd of Yale.

* * *

Get the 2,500.

* * *

GET out and get that member. We need the 2,500 before March. Look at what we were able to do with the support of 1,200 members and think of what we could do with the additional support.

RECENT ACCOMPLISHMENTS

1. Erection of Engineering Camp at East Lyme, Conn., giving Yale the best of its kind in the world.
2. Erection at Bowl of Memorial Tablet to the designer, Charles A. Ferry, '71 S.
3. Having University authorize Committee on Architectural Plan to prepare preliminary sketches for new building to replace South Sheffield Hall.
4. Co-operating with the new Yale Scientific Magazine by subscribing for copies to be sent to every member of the Association.
5. Representing in an organized way the Alumni of "Sheft" to help the Faculty and University solve many problems for the best interests of Yale.

THE VISION OF YALE'S ALUMNI FOR THE SHEFFIELD SCIENTIFIC SCHOOL

The following address was delivered by Dr. O. S. Lyford, '90 S., former President of the Yale Engineering Association, as one of the radio talks in connection with the Electrical Engineering Exhibition by the students of the department in Dunham Laboratory on December 9th, 1927:

"*Ladies and Gentlemen:*

"I speak for those Alumni of Yale, who carry responsibilities of leadership in industry in this country,—the scientists, engineers and administrators who have gone out from Yale to direct the planning, the production and the distribution of the necessities and the comforts of life.

"I ask that when you next take up a great New York daily paper and review the financial pages and consider the record of the stocks and bonds you own or would like to own, you visualize the hundreds of industrial establishments represented in those pages, the millions of stockholders and employees dependent on them and the billions of dollars invested in them. The success of these enterprises and the welfare of the people connected therewith, as well as that of the whole population of the country, depends in large measure on the ideals, the vision, the correct thinking, the powers of organization and leadership, and the hard work of the men at the heads of the various corporations and their departments.

"This is the picture constantly before those Alumni of Yale who are endeavoring to assist our great University in its development to meet the expanding needs of the nation. Yale has unusual responsibilities and opportunities. It is essentially a national University as indicated by the present Freshman class, which came from forty-three states, the District of Columbia, and Hawaii. It is looked up to as a leader in educational matters and its facilities for instruction and research are exceptional. The contacts with men from all parts of the country and the life in its halls and on its campuses develop a spirit which is proverbial. To have been under these influences,—to be a Yale man,—therefore, is not only a great privilege, it is a great responsibility, and this is felt by many of its Alumni.

"The Yale Engineering Association is a body of about 1,500 of these Alumni who are banded together to add strength to the University in any practical way. We are continually in touch with the institution and watch its development with great interest, particularly that of the Sheffield Scienific School.

"We know from personal experience and from observation of the development of the young men from the Scientific School whom we have employed, that this thing known as Yale Spirit is something real, something that develops the personality of leadership. It is therefore something which enables a man to carry responsibilities. Testimony to this fact is born by prominent industrialists from all parts of the country.

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NEW METHODS USED IN MEDICAL EDUCATION

(Continued from page 28)

Policies of Yale Medical School.

The changes which have been made in the medical curriculum are based on two fundamental principles of education. The first is that every student must in the last analysis train himself. To accomplish this end courses and credits and examinations as such, have been reduced to a minimum. The student's aim has been directed toward the fundamentals of medicine as an objective. Opportunity is offered each and every student to familiarize himself with the fundamental principles of the science of medicine. He is guided and helped in this study by every known means. Obviously the most effective of these is the contact of the student with men who are leaders in their fields. It is here that the strength of the school of medicine lies. The second fundamental principle is the belief that all students need some test of their accomplishment, need to be presented with situations which test their proficiency in their fields of study. To accomplish this, frequent opportunity is offered to the student to check his knowledge against the knowledge of the members of the faculty, and he is expected to present progress reports of his work from time to time. But more particularly when a student has completed one section of his study of the medical sciences, he comes before an examining board for a comprehensive examination. In practice this means that each student in the school of medicine when he has convinced himself that he is prepared to take it must submit himself to an examination covering the preclinical sciences. Ordinarily the student must spend two years in preparation for this examination. This time may be, however, lengthened or shortened depending on individual circumstances. Furthermore, this examination is designed to satisfy the faculty of the clinical years that the students who successfully meet the conditions of the examination are equipped to enter upon their study of the patients in the hospital. Once having successfully entered the clinical years the student continues in his study of the medical sciences particularly as they are related to the sick. Ordinarily the two years are spent in this aspect of their medical work, and again, when each student is convinced of his progress, he may present himself for an examination covering his entire clinical work.

Finally throughout his entire residence in the school of medicine each student is expected to engage in some investigation relating to his chief interests. While occupying the relatively small proportion of his total time, nevertheless, such an investigation represents one of the most effective tools devised for assisting men in their own education. It is, therefore, a fundamental part of the medical school course. Successful completion of the two comprehensive examinations and the presentation of an adequate thesis is required of all men before they are granted the degree of Doctor of Medicine.

The Yale School of Medicine then, offers to student and teacher alike opportunity for study of the medical sciences and facilities and stimulation for research in those sciences. Students and faculty alike are banded together for the furtherance of medical knowledge. The spirit of the group justifies the individual in the hope of self-development, that he may the more successfully contribute to the welfare of his day and generation, and to the body of knowledge which will be used by those who come after him.

James Dowling Trask has been transferred from Assistant Professor of Medicine, Yale University School of Medicine, 1925-27, to Associate Professor of Pediatrics, Associate Pediatrician, New Haven Hospital.

MATHEMATICS

(*Continued from page 30*)

subject was "Mathematical Rigor, Past and Present."

Papers Presented to the American Mathematical Society by Other Faculty Members.

In addition to the invitation lectures by Professors Brown and Pierpont, three other members of the department read papers before the American Mathematical Society. These were Professors Gehman and Ore and Dr. Rawles.

Absent on Leave.

During the second semester Professor E. W. Brown will be on leave of absence. He will go to Pasadena, Calif.

Former Members of the Department Called to New Positions.

Dr. M. C. Foster, formerly an instructor at Yale, and more recently Assistant Professor of Mathematics at Williams College, has been made Associate Professor of Mathematics at Wesleyan University.

Dr. W. L. Crum, Associate Professor at Harvard, has resigned this position in order to accept the Professorship of Statistics at Leland Stanford Junior University. Dr. Crum was formerly an instructor at Yale.

Professor Brown, Sterling Professor of Mathematics, was elected to membership in the Belgian Academy of Sciences.

Professor Brown will be on Sabbatical leave for the second term of this year. He is intending to spend a good part of this leave in Pasadena, California.

ELECTRICAL ENGINEERING

(*Continued from page 30*)

H. V. Bozell (formerly on the staff of this Department), with Bonbright & Co., of New York, "Present Attitude of the Public Toward the Electric Service Companies."

E. C. Stone, Chairman, Engineering National Section, National Electric Light Association, "Problems of the Engineer in the Power Industry."

F. C. Holtz, Vice-President and Chief Engineer, Sangamo Electric Company, Springfield, Ill., "Watthour Meter Compensation and Characteristics."

Student Exhibition.

The seventh student electrical exhibition was given by the electrical students early in December. A new feature of the exhibition was a number of talks by prominent Yale men and eminent engineers which were broadcast. These talks presented many of the developments in engineering and set forth the opportunities for graduates in this field.

Electron Voltmeter.

Professor H. M. Turner has recently developed a compensated electron tube voltmeter, the calibration of which is independent of the filament current between the limits of 10% above and below the normal value. He has recently conducted research in connection with the committee work of the Institute of Radio Engineers on methods of measuring circuit constants, particularly with reference to large values of inductance and capacity. He is also serving on committees on Instruments and Measurements and of Communication of the American Institute of Electrical Engineers.

Electric Heat.

The Conference on Electric Heat Treatment of Metals conducted by this Department in co-operation with the Manufacturers' Association of Connecticut brought together a group of 200 interested persons. A notable feature was the description of the large use of electricity for improving the quality of materials in the automobile industry. Reports from ten installations for electric heat in New England showed large savings in the cost of labor and of handling materials as well as excellence of quality in the product. It is probable that similar conferences on other subjects will follow.

In addition to the electrical classes in the New Haven College (Y. M. C. A.) which are being taught by members of this department, a special course for foremen in New Haven industries is being conducted in the form of a course of evening lectures under the supervision of Professors Knowlton and Hall.

Electrical Units.

The legal values of the fundamental units of electrical measurements, the ohm, the volt, the ampere, are matters of legislative enactment and international agreement. At the time when Congress fixed the value of these units it appeared most feasible to set up as directly as possible a physical standard to serve as the American replicas of the international standards.

With improvement in precision of measurement it now known that the "mercury" ohm (the legalized international unit) differs by 0.05 per cent from the absolute c.g.s. ohm; also that the ampere obtained through the legal standard silver voltameter differs by 0.01 per cent from the absolute ampere.

Professor A. E. Knowlton of the Electrical Engineering Department has been appointed, with Dr. H. B. Brooks of the United States Bureau of Standards, to constitute a committee which will prepare for submission to Congress resolutions framed to correct the discrepancies. These resolutions will be presented to Congress by the Board of Directors of the American Institute of Electrical Engineers after approval by its Committee on Standards and the Committee on Instruments and Measurements. Messrs. Brooks and Knowlton are members of the latter committee.

CHEMISTRY

(*Continued from page 30*)

and read two papers entitled, respectively, "Some Local Anesthetics of the Napthalene Series," and "The Organic Chemistry Courses for the Pre-Medical Students."

Professor A. J. Hill is working on problems dealing with the relations between the chemical constitution of organic compounds and their physiological action and fundamental problems dealing with the promotion of organic reactions by means of catlysts.

These lectures have been given in Graduate School Seminars since the last issue:

Professor A. W. Browne of Cornell University, "Oxidation."

Professor James Kendall of New York University, "Rare Earths and Isotopes."

Dr. Norman A. Shepard of the Firestone Tire and Rubber Company, "The Role of Chemistry in the Rubber Industry."

Professor Lafayette B. Mendel of the Physiological Chemistry Department, "Recent Developments in Physiological Chemistry."

Professor Herbert S. Harned of the University of Pennsylvania, "Some Recent Results on Homogeneous Catalysis."

Mr. L. V. Redman of the Bakelite Corporation, "The Manufacture of Bakelite."

Dr. Harry L. Gray of Eastman Kodak Company, "Recent Developments in the Chemistry of Cellulose."

BOTANY

(*Continued from page 31*)

Mr. Albert A. Dunlap is investigating the nitrogen and carbohydrate content of healthy squash and tobacco plants and those with the mosaic disease.

Mr. George L. Zundel is completing a monograph on the smuts of the world.

FORESTRY

(*Continued from page 31*)

in the 11,500 specimens at the School of Forestry. No such collections of authentic material exist elsewhere, and Dr. N. L. Britton, Director-in-Chief of the New York Botanical Garden, recently stated that "Yale's accumulation of wood specimens is astounding."

The object of the collections is to provide material for a comprehensive and comparative study of woods which will permit of their proper classification. Mu-

seums, forestry departments, educational institutions, and various commercial concerns in both hemispheres are contributing specimens, and specialists are already working on such groups as are near enough to completion to permit systematic investigation. Such an undertaking is of fundamental importance to the knowledge of the forest resources of the world and their conservative utilization. The results will also be of far-reaching scientific importance, particularly so to botanists, since the classification of all woody plants, both living and fossil, will be greatly simplified.

Forest Taxation in New Hampshire.

Professor Toumey has been assembling data on forest taxation, on a number of forest properties in southern New Hampshire, not far from the Demonstration and Research Forest near Keene. These data show that the increase in annual taxes on second growth that has been well managed, in twenty-five years is from five hundred to eight hundred per cent. This has been due both to increased valuation for assessment purposes and to the increased tax rate. Some forest properties which twenty-five years ago paid an annual tax of \$.20 to \$.50 per acre now pay as high as \$5.00 to \$10.00. The value of second growth for purposes of taxation is based on the full sale value of the standing timber. Under this system of taxation the owner of second growth of high value is forced to cut his timber when thirty-five or forty years old in order to escape an annual tax which, if the timber is held longer, is often greater than the value of the added growth of the year.

A paper has been prepared embodying the results of this investigation. The title of this paper is, "What Ails New England Forests?"

Professor Hawley, who has charge of the silvicultural work in the forests of the New Haven Water Company, has been using spare time during the fall months in marking timber and initiating cutting operations on portions of the new properties acquired by the company in Guilford and Madison. On prospective reservoir sites and canal lines it will be necessary to remove the entire forest cover. Elsewhere partial cuttings to remove mature timber, injured and dying trees and inferior species are applied with the object of maintaining continuously a healthy forest cover as a protection to the watersheds.

George A. Garratt, Assistant Professor of Forest Products, is co-operating with the Trimpak Corporation of New York, in an investigation of "fireproof" wood, to determine the practicability of several new impregnation treatments which have recently been devised.

Medicine

Appointments School of Medicine.

Francis Gilman Blake, John Slade Ely Professor of Medicine, has returned from year in Europe.

Raymond Hussey has been appointed Professor of Pathology and Pathologist at New Haven Hospital.

Arthur Henry Morse has been transferred from Professor of Obstetrics and Gynecology to Obstetrician and Gynecologist-in-Chief, New Haven Hospital. He has just returned from a sabattical year in Europe.

Grover Francis Powers has been transferred from Professor of Pediatrics, Yale University School of Medicine, to Pediatrician-in-Chief, New Haven Hospital; Chief of Service, Pediatrics Clinic, New Haven Dispensary.

Harold Myers Marvin has been transferred from Assistant Professor of Medicine to Associate Physician New Haven Hospital and Medical Clinic, New Haven Dispensary.

RESEARCH ADVANCES PHYSICAL KNOWLEDGE

(*Continued from page 21*)

the formation of ordinary chemical compounds. Besides this a study of alpha-ray straggling and another on the ratio of the number of gamma-rays to the number of disintegrating atoms from which they come are being undertaken by graduate students under Professor Kovarik's direction.

Precision measurement of X-ray wave-lengths, involving as it does the elimination of experimental errors exceeding a few parts in a million, demands a very high order of technical ability, great ingenuity, and almost infinite patience. Dr. C. D. Cooksey and his brother, Mr. Donald Cooksey, who combine these desiderata, have devised and constructed instruments of the necessary refinement and hope shortly to reach or to surpass the quality of the best work of this kind so far reported from other laboratories.

The new interest of chemists in the use of physical methods in attacking their special problems is shown by the fact that two of the spectroscopic problems under way in the Sloane Laboratory are being conducted by Dr. Black, Commonwealth Fellow in the Department of Chemistry, and by a candidate for the Ph.D. degree in the same department. The band spectra of certain organic compounds will, it is hoped, permit them to decide between various structures of the molecule which are equally probable in the light of chemical evidence alone. This work and other spectroscopic problems are directed by Professor Uhler, who has been closely associated with the best work done at Yale in this field of physics. Now that the theories of atomic structure receive their most severe tests in the interpretation of spectra the exact measurement of visible and ultraviolet emission lines is increasingly important. Dr. Kinsey, who holds a National Research Council Fellowship in Physics, is also working with Professor Uhler on optical problems, particularly on the re-emission of light ("resonance radiation") from metal vapors under intense illumination. A heliostat mounted on the southern face of the laboratory, just outside an attic window, is the rather conspicuous means by which radiation of sufficient intensity has been brought to bear upon the vapor under observation.

Dr. Lawrence and Dr. Beams are engaged in a series of researches into the time necessary for the appearance and disappearance of the effects of electric and magnetic fields upon the transmission of light. These effects, long known by the names of their discoverers, Kerr and Faraday, have been supposed to appear and disappear instantly with the application and removal of the appropriate field. In the experiments now in progress the light passes through two "Kerr" or two "Faraday" cells in succession, the electric or magnetic fields being timed to arrive at suitable moments by making the currents which produce them travel over longer or shorter sections of long copper wires not unlike antennae for radio reception. If the "effect" begins later or lasts longer in one of the cells this results in a change in the transmission characteristics of the combination. An idea of the precision possible can be gained by considering that changing the position of either cell by only a few centimeters along the ray of light, corresponding to a time difference of much less than a billionth of a second, produces an observable change in the transmitted light. Similar methods are also being applied to the measurement of the time light must shine upon a metal surface before the so-called photo-electrons begin to be emitted from it.

Among the other members of the faculty who are engaged in experimental researches are Mr. Gardiner, who is investigating the proportion of absorbed radiation which reappears in the energy of photo-electrons, and Mr. Henderson, who is trying to fix the angles at which soft X-rays, i.e., X-rays of long wave-length, suffer total reflection from various materials. This total reflection is one of the most interesting facts recently discovered about X-rays and preliminary work on the critical angles for reflection was done two years ago by Professor Elizabeth Laird of Mt. Holyoke as a visitor in the Sloane Laboratory.

ELECTRICITY IMPORTANT IN PROSPERITY

(*Continued from page 12*)

extensions. In the years 1925-6 the new capital enlisted in the electric utility business has amounted to 37% of the total corporate financing of the country. This fraction is so much higher than the corresponding ratio between the total gross volume of electric power sales and sales of ordinary business enterprise partly because (1) ordinary business commonly uses surplus to finance enlarged plant and activities, whereas this procedure in public utility business is not sanctioned to any appreciable extent by regulatory bodies and (2) a utility business takes in only about $1 per year of gross revenue for about every $5 invested in plant, whereas the ordinary business venture commonly takes in $5 a year for each $1 invested in plant and stock.

About 200,000 employees are engaged in rendering electric service to the American public. The power output of the systems which they are manning, when applied for the benefit of and directed by the other 12,500,000 workers gainfully employed in industry, supports the present scale of quantity production. Domestic consumption of the output of commodities of American industry has kept pace with an increased productivity because it has been possible at the same time to share with the workers, through higher wages, a portion of the savings in costs of production as rendered possible by increased use of power in industry. If, then, purchasing power is taken as an index of prosperity it seems that it cannot be denied that electric power is an important factor contributing to the unparalleled prosperity of the last five years in the United States.

"A LANDMARK IN HISTORY"

In connection with Professor Charles F. Scott's editorial in this issue it is interesting to note the following article which appeared in a recent issue of the *Proceedings of the American Society of Civil Engineers* under the above head:

"A remark most significant to the Engineering Profession is made by Mr. Mark Sullivan in his article appearing in *The Sunday Constitution Magazine* of January 8th last. The author of "Our Times," and "The Turn of the Century," commenting on "Politics in 1928," queries: 'Will Prohibition, Religion, or Farm Relief Be Our Outstanding Issue, or Will It Be Something Entirely Unforeseen by the Prophets?'

"The significance to us as engineers, however, lies in Mr. Sullivan's concluding paragraph. He says:

"'I suspect the future historian will treat the Coolidge and Harding administrations as one. Probably he will add several future administrations to them and group all as a new era. The symbol of the change he will probably find in an event—the presence for the first time of a man with the letters C.E. (civil engineer) after his name in the higher circles of politics. The man happened to be Hoover. It might have been some one else. A democrat, Owen Young, would have the same significance. The thing that Hoover symbolized—the recognition of the immensely exalted role of science in social and political organization—that is what will be recognized as constituting a landmark in history.'

"Although Mr. Hoover is an Honorary Member of the Society, his training and experience are that of a Mining Engineer. However, that's beside the issue. The point, it seems, is Mr. Sullivan's shrewd suggestion that the entrance of engineering into public administration will be recognized as 'constituting a landmark in history.'"

YALE TO EXCAVATE ANCIENT CITY

(*Continued from page 28*)

ernment had sufficient funds for systematically excavating the ruins.

In 1926, the Committee on Excavations in the Orient at Yale, headed by Professor Charles C. Torrey, came to the conclusion that it would be a great service to learning if excavation work at Dura were renewed. President James Rowland Angell of Yale and the Committee authorized Professor Rostovtzeff to discuss with the French Academy and the Syrian Government the possibilities of doing this, with the result that Professor ostovtzeff was fortunate enough to receive the support of the Academy, and the assurance of its collaboration if the necessary funds were secured. The matter was taken up with the Syrian Government, and last year Maurice Pillet, noted architect and archaeo logist, was sent to Dura to study the question of continuing the work of excavation. Mr. Pillet reached an agreement with the Syrian Government by which Yale received the concession for excavating the citv for six years. In the fall of 1927 the General Education Board of New York abreed to give the University funds which would ensure excavations for three years.

The University hopes to begin excavating this spring. Mr. Pillet has been appointed Director of the expedition. He has worked for many years in the famous excavations of De Morgan at Susa in Persia, and recently published a book devoted to the restoration of the ruins of the palace of Darius, at Susa, one of the Persian Empire's capitals. For many years he was in charge of excavations and restorations of the Temple of Karnac in Egypt, which is so well known to tourists. His Research Associate will be Clark Hopkins, Ph.D., of Yale University.

It is hoped that the excavations will yield very important and rich material for illustrating the development of Greek civilization in the East, and the Hellenization of the Orient. It must be emphasized that this excavation is not expected to be difficult, since Dura has been buried merely under the sand of the desert, as Pompei was buried for centuries under the ashes of Vesuvius.

APPOINTMENT OF PROFESSOR OF PHYSICAL CHEMISTRY

The University has announced the appointment of Herbert Spencer Harned, Ph.D., now Professor of Physical Chemistry at the University of Pennsylvania, as Professor of Physical Chemistry at Yale.

Professor Harned holds the B.A., B.S. and Ph.D. degrees at the University of Pennsylvania, and has been a member of the Faculty of the University of Pennsylvania since 1913, as instructor, lecturer, assistant professor, and as professor. He has published many articles in the *Journal of the American Chemical Society*.

SHEPAUG TUNNEL OF GEOLOGICAL INTEREST

(*Continued from page 16*)

early in the Paleozoic Era. In the same way the Hartland schist though now regarded as Ordovician or Silurian and though almost certainly younger than the Berkshire schist may also prove to be a pre-Cambrian rock.

At the present time these two schists occupy the opposite sides of the Green Mountain plateau, composed of the oldest sedimentary and igneous rocks, that passes down through Massachusetts and into Connecticut in the region of Norfolk, the Berkshire lying on the west and the Hartland on the east. These two approach each other in northern Massachusetts at Hoosac Mountain and come into contact around Litchfield, Connecticut, in the region of the tunnel. This tunnel intersects the schists, as we have seen, in a region where the Brookfield diorite lies between them, so the contact is nowhere actually visible.

The Brookfield diorite, which, as we saw is in part gneissic, must for that reason have been in existence at least when the last great mountain-making and metamorphism occurred. It is younger than either the Berkshire or the Hartland schists, since it has intruded them both, but no closer approximation can be made to its true age.

The peneplanation of the whole eastern part of the country mentioned above occurred near the end of the Mesozoic era. The sea flooded widely over the North American continent at that time and the Connecticut shore probably lay much farther north than it does today. The planing effect of the waves near the shore had much to do with levelling off the old land surface, and the successive stands of the sea can now be recognized in the step-like rise of the land from the present shore to the northern part of the state. That period of low lands was followed by a doming up of the worn-down mountains to a height somewhat greater than their present elevation. The uplift initiated the cycle of stream erosion that has gone on, with changes of course, to the present day. The old streams incised their courses, and new ones developed upon the old surface of the land until the valleys were cut out, mostly on the less resistant rocks, and the interstream divides alone showed by their accordant summit levels the previous existence of a flat plateau. This is still a very noticeable feature of the region around Litchfield.

Geological Change Attributed to Glacier.

The last event to record was the coming of the ice sheet in the Pleistocene period, the geological yesterday. Due to the interaction of various factors, little understood, a considerable lowering of the average temperature and probably an increased precipitation caused ice caps to form over much of the northern part of the globe. The southern limit of the glacier in North America was south of Connecticut, so that the whole region with which we are dealing was buried under the ice, and considerable change in the surface is attributed to it. Soil and weathered rock were carried away; the fresh rock surface was scratched and polished by the materials dragged over it in the grip of the ice; valleys were deepened a little, and hills worn off. Finally the ice withdrew, dropped its load as it melted, and left a veneer of unsorted boulders, sand and gravel, unevenly distributed over the surface; hummocks and mounds of the same debris, the moraines, where the ice front stood still long enough for the material to accumulate; and formed long, ovate hills of the same material, the drumlines, elongated parallel to the direction of the motion of the ice.

At the time when the land surface around Litchfield emerged from the ice, old drainage channels were blocked, lakes and swamps had formed in the old stream valleys, the hills were a little lower, and the system of streams that had developed by adjustment to the rock and structure of the region through long ages was completely disorganized.

Since that time the early swamps have become meadows, the smaller lakes have been filled in by vegetable matter and sediment until they are now swamps. The bed rock has begun to weather; erosion has altered the contours of some of the glacially deposited materials, streams have carried away part of the till; some found their old buried courses once more, while others have definitely started to cut new channels through bed rock, as in the case of the Bantam River below Bantam Lake.

The surface of this region then shows a blending of the pre-glacial mature topography and the youthful features superimposed upon it by the disorganizing effect of the ice-dumped debris, one step only in the slow but inevitable progression towards a new peneplain that will end the present cycle of erosion.

VISION OF YALE'S ALUMNI FOR THE SHEFFIELD SCIENTIFIC SCHOOL

(*Continued from page 32*)

"Obviously it is important that the boys who are admitted to Yale shall have the natural physical, mental and spiritual qualities which can be adequately developed under its influences and training and thus may be relied upon to sustain the tradition that the stamp of 'Yale' on a man means that he is capable of becoming an important factor in the life of the nation.

"This means also that our methods of testing the fitness of candidates for admission must be such that the greatest possible proportion of each class shall have these high qualities and also high purpose. The time has come when the mere passing of a series of written examinations is not sufficient for admission. Our Association is in close touch with the Board of Admission and we are much impressed with its tests, which go far beyond the conventional examinations.

"The power to become an effective citizen is hard to measure in a boy of eighteen, but that Yale is developing this power is evidenced by the great decrease in the class mortalities,—the number that drop out before graduation. This means much to the boy and his father, as well as to the University, as it is evidence that the time and money invested in the boy's education will probably be well utilized.

"The new Yale Department of Personnel Study will be of great assistance to the individual students in regard to their courses of study and the careers which will probably be open to them after graduation. If the boy makes good use of this assistance, there is therefore, an increased probability that his success after graduation will justify the time and expense and effort which will have gone into his education.

"Now that these methods are well established in conjunction with Yale's eminent teaching staff and its great laboratories, we feel that we may expect that there will be a continually increasing proportion of graduates of this School who will be capable of carrying large technical and administrative responsibilities in the field of commerce and industry.

"This is the vision of Yale's Alumni for the Sheffield Scientific School."

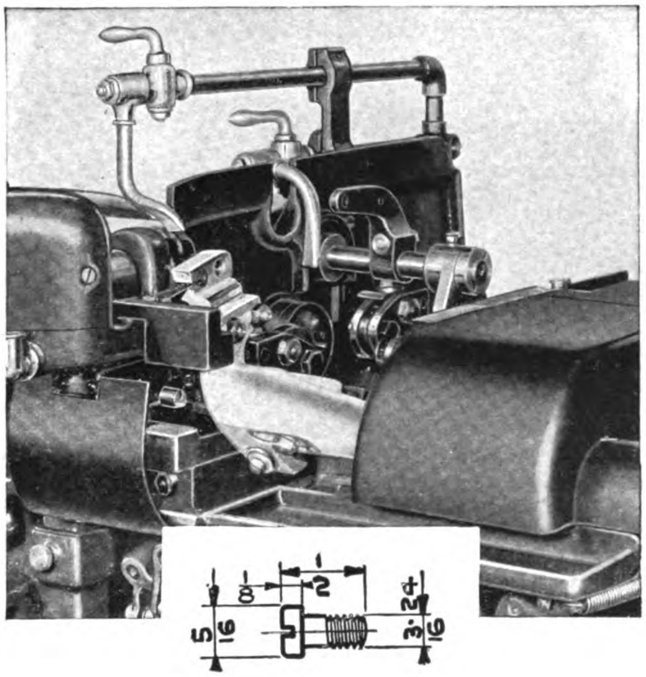
MATHEMATICS

Former Instructor Honored.

T. W. Moore, Ph.D., Yale 1927, was granted a National Research Fellowship in Mathematics for the year 1927-28. Dr. Moore was a member of the department for three years.

Instructor Accepts New Position.

Dr. L. S. Hill (Ph.D. Yale 1926) has accepted a position in Hunter College.



CONCRETE—ITS SUCCESSES AND FAILURES

(*Continued from page 10*)

crete does not benefit to any appreciable degree from the addition of integral waterproofing compounds and that a poorly designed mixture cannot be made "waterproof" by the use of even the best admixture. Between these two extremes a waterproofing material may be of some slight value, particularly in thin sections, such as stucco applications where such would appear to add a factor of safety to the mixtures as ordinarily employed. In concrete construction the best practice would tend toward a careful grading, mixing and depositing of the materials rather than the use of integral waterproofing compounds.

Another problem that confronts the designer in concrete is the effect of the climatic variations on his material. For many years we have known that concrete was expanded by heat and contracted by cold. Fortunately this variation, about five-eighths of an inch in one hundred feet for a variation in temperature of one hundred degrees Fahrenheit, is approximately that of structural steel. Only comparatively recently have we had definite data in regard to the influence of moisture on hardened concrete, which, combined with somewhat earlier studies, principally of European origin, dealing with the initial contraction that takes place during the early stages of hardening, have enabled us to estimate quite accurately the probable change in volume that must be provided for in design.

The difficulty arises not in design but in the field, and many of our most imposing structures have suffered partial failure due to inadequate provision for expansion and contraction. It is not possible to lay down any definite rule as to the frequency of joints in continuous structures, or to recommend any particular type of joint that will always be appropriate. In buildings much over three hundred feet in length most designers prefer to insert one transverse joint completely dividing the building into two sections. A large manufacturing plant built a few years ago had one joint in the center dividing an eight-hundred foot building into two units, each four hundred feet long. This joint opened and closed with temperature changes to an extent that was easily discernable.

In the construction of retaining walls and parapets joints are particularly necessary. Where panels are separated by posts or pilasters it may often be possible to cast the panels first. If this can be done it is then a simple matter to paint the ends adjoining the posts with mastic for a distance of perhaps two inches. The posts are then cast, allowing the hardened panels, coated with the joint forming mastic, to project two inches inside the faces of the posts, which thus form a groove to receive the panel and permit its movement without cracking. If this, or some similar method is not applied, the walls will probably crack at the junction of panel and pilaster.

These various details, brief as this outline has been, should serve as an illustration of how futile it is to employ inexperienced individuals to design and construct concrete work. Many engineers of long experience in structural steel and other types of masonry, have been responsible for grave errors and partial failures in this field. Reinforced concrete is a distinct branch of structural engineering. When the public is educated to regard it as such, employing in responsible positions only those engineers and builders who have made this field their specialty, we will no longer have to blame our own ignorance upon the deficiencies of the material.

PERSONALITY

(*Continued from page 29*)

profitable. His lectures are made fascinating by his vast knowledge of medical history and of men who have created the science of modern medicine.

By his researches he has made a number of fundamental contributions in his field. Much of his work has been on circulation of the blood, respiration and anesthesia. He has written several very interesting papers based on experiments on the physiological qualities of athletics. The results of his observations on the Olympic Championship Crew of 1924 excited much popular interest. Many of his papers show how well acquainted he is in other fields of science. To say that he knows more thermodynamics or electricity than most medical men would be damning him with faint praise. Because of his tremendous interest in and knowledge of literature along with the association and guidance of his scholarly colleague he has developed a literary style of a vigor and originality that few scientific authors possess. His research activities are remarkable for both profundity and range. His work on the Holland tunnel is among the physiological problems with an important industrial bearing in which he has been associated. Much of his work goes unwritten and unpublished, for he loses interest in his problems after he has solved them experimentally. It is only through the persistent efforts of Dr. Henderson that many of his papers are written.

He knows and has dealt with perhaps more publishers than any author of his age. The first manuscript he ever attempted to publish was refused by no less than ten publishers. He was even accused of establishing his sons (eldest aged 8 years) in the printing business with the express purpose of getting his first book published. After considerable travel it was accepted and is being published in serial form in the popular medical monthly magazine *Hygeia.* This serial is titled "Junior and Mr. Germ," and was written for his children and his own amusement. Among his first important scientific publications was "Noxious Gases," written in co-authorship with Professor Henderson. This book is the result of their many years of study and experiment and is the leading authority in its field. Recently he completed a textbook on which he spent several years for his course in Industrial Physiology. It is entitled the "Science of Health and Disease." His friends call attention to the fact that unlike another book on "Science and Health" it contains no key to the scriptures. This text-book extends over the whole field of modern medicine, and is written simply and clearly so as to make the accumulated knowledge of this vast technical field available to the general reader. Besides his writing, lecturing and research he does con-

(*Continued on page 46*)

PERSONALITIES

(*Continued from page 45*)

siderable consulting work and is often asked to give expert testimony.

He lives on his farm in Woodbridge, and there, with his wife and three children, he enjoys an ideal domestic life. His attractive and most comfortable old colonial home reflects much of the taste and character of its owner. For a while he practised farming as an avocation, but he found that a practical education in agriculture costs more than a medical education.

He hates to have it suggested that he is of Irish ancestors by being called Haggerty, for he says Haggard is *not* an Irish name.

He is most interesting and at his best with a lucky strike and a cup of coffee after a fifty-cent luncheon at Commons.

The species "boobus americanus" amuse him very much and he regrets that there is but one Chicago.

A dean once told a student who wished to elect his course that he would be wasting his time, since his mother had, undoubtedly, taught him all that Dr. Haggard could teach him.

A student once asked in class for Dr. Haggard's opinion on the use of alcohol. Before replying he inquired, "Is that an invitation?"

Part of his lecture period he devotes to answering questions. Seldom if ever, is he baffled by one of the numerous and heterogenous mass of questions asked. However, he objects to being asked if sterility is inheritable.

Students who have tried it claim it is impossible to sleep through his lectures, no matter how the previous night was spent.

He suffers from lumbago and lead tetraethyl.

Social functions annoy him and he never attends them when he can avoid them.

His laboratory assistant says he works harder than any man in the University.

He has the heart of a humorist and a stomach that can digest anything.

He takes no exercise nor does he play contract bridge.

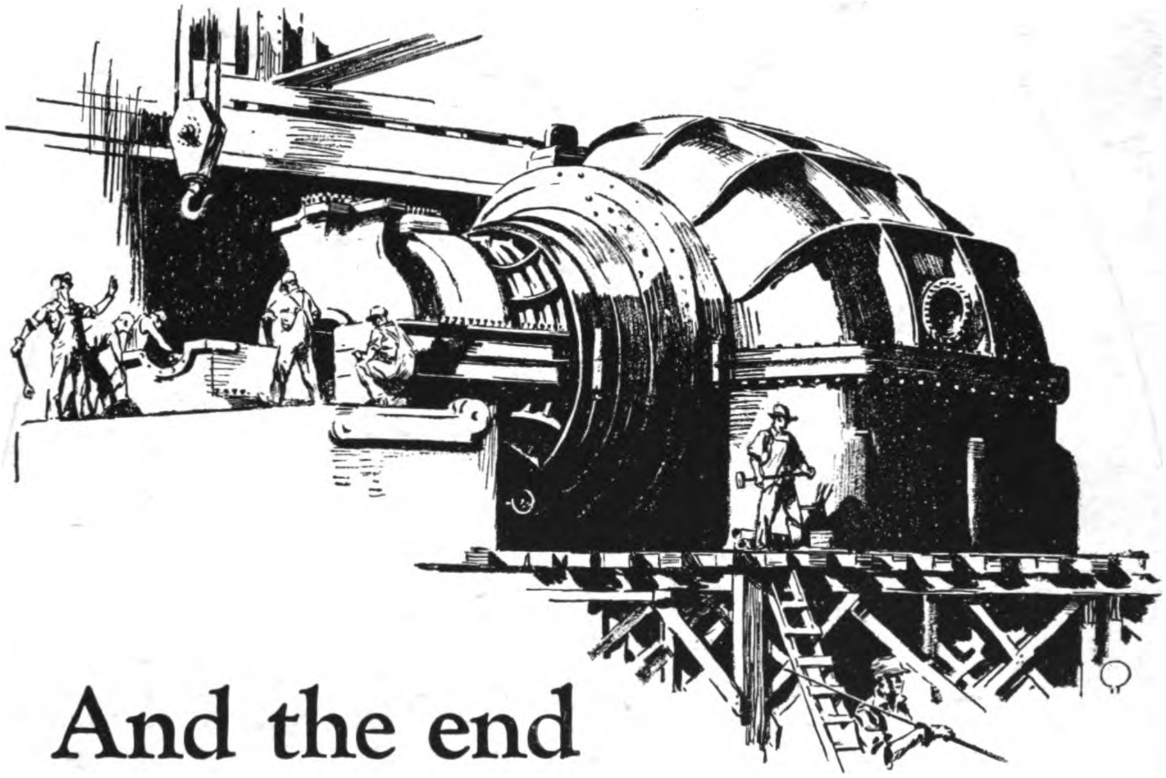
He reads approximately a half million words a week and retains most of what he reads. He writes on an average of five thousand words a week.

PHYSICS DEPARTMENT

Dr. Ross Gunn has left to take a position in the Naval Research Laboratory in Washington.

Dr. P. H. Dowling has left to take a position in the research laboratory of the Union Switch & Signal Co., of Pittsburgh.

Mr. W. E. Deming has left to take a position in the Fixed Nitrogen Research Laboratory in Washington.



And the end is not yet in sight

In the year that many of today's college students were born, a new child—the steam turbine—came into the industrial world. Its birth was celebrated by the installation of a 5000-kw. unit, in 1903. In 24 years the turbine has grown to giant size, with a 165,000-kw. unit to go into operation in 1928, and a 208,000-kw. unit under construction.

Experienced engineers have made outstanding contributions to its development—making possible these tremendous units. A young engineer, only a few years out of college, has by "flow casts" enabled designers to visualize the flow of steam through the intricate passages within the turbine. This has resulted in an improved design of nozzles and buckets. Others have eliminated the causes of resonant vibration and have made possible the production of units which operate at 1200-lb. pressure and 750 degrees F.

Greater power plant efficiency is being obtained by the extraction of steam from the turbine at different temperatures to heat feed-water on its way to the boiler, and the economies of the mercury vapor process indicate a new range of possibilities.

Rome wasn't built in a day, nor was it built by one man. The power plant, which now delivers a kilowatt-hour of electricity for one-third as much coal as it took a quarter-century ago, is the combined achievement of many engineers working not only on turbines, but on generators, boilers, and the many auxiliary devices. These men have helped to give the world a new force. Progressive leaders in all fields are calling upon electricity for ever-widening services—and the end is not yet in sight.

This monogram identifies the accomplishment of General Electric scientists and engineers. You will find it in power houses, on small motors in the home, on powerful electric locomotives, and in the electrified factories of modern industry.

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GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

THE YALE SCIENTIFIC MAGAZINE

VOL. II MARCH, 1928 No. 3

A Survey of Modern Marine Engineering
PROF. HERBERT L. SEWARD, 1906S

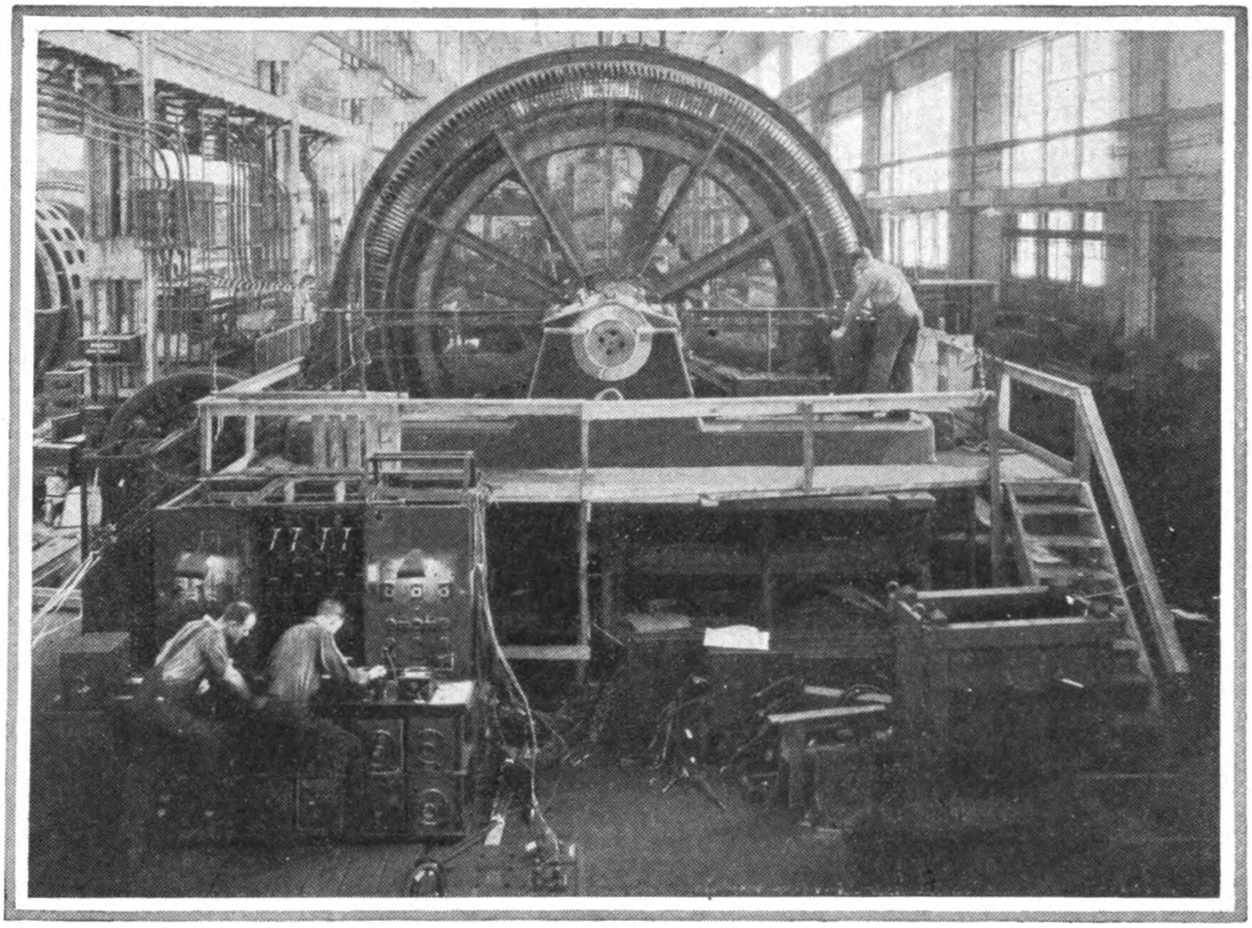
Venezuela Second in World Oil Production
CASSIUS A. FISHER

Important Discoveries in Glacial Geology
PROF. RICHARD F. FLINT

Better Utilization of Coal Being Attained
PROF. HARRY A. CURTIS

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL

PRICE FORTY CENTS



Responsibility

A year ago, these young men were studying engineering in college class rooms. Here we see them putting a 5000-horsepower synchronous motor through its paces. As G-E Test Men, they have charge of this work; upon them rests a definite responsibility for determining whether this machine measures up to G-E standards of performance and will worthily represent General Electric in the service of the customer.

Opportunities such as these mean much to the industry as well as to the man, for the future leaders of the great electrical manufacturing and electric power companies must of necessity be those who have learned to assume responsibilities.

The General Electric monogram is the symbol of an organization whose engineers have met their responsibilities by establishing principles and developing apparatus which have made General Electric a leader in the great electrical industry.

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THE YALE SCIENTIFIC MAGAZINE

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From The Editors

WITH this issue, THE YALE SCIENTIFIC MAGAZINE completes its first year of existence as a publication in the interests of science and engineering in the Sheffield Scientific School. Four issues have been published to date, and, with the appearance of this number the management changes from the hands of the senior board to those of the junior board: we wish the new editors every success for the year to come, and will do all we can to cooperate with them in handling the May issue.

We believe that the magazine is now on a firm basis, and that there is every indication of its becoming an important factor to all those interested in the activities of the scientists and engineers connected directly or indirectly with the University. To increase this interest, we wish to impress upon the minds of the readers that any communications, whether in the form of short anecdotes or complete articles, will be appreciated and will receive careful consideration as material for the magazine. In this way, more articles will be obtained from the graduates, and will more evenly balance the contents of the publication.

* * * *

The Advisory Board and the faculty as a whole have been of the utmost importance in submitting articles and in giving advice and suggestions whenever called upon. We take this opportunity to extend our sincere thanks, and hope that the relation has been and will continue to be as pleasant to them as to the editors.

A Survey of Modern Marine Engineering

Diesel Engines, Electric Drive, Improved Condensers and Vacuum Apparatus Among Motivation Aavancements. Navigation Aids Include "Metal Mike" Fathometer and Gyro-Compass.

Prof. HERBERT L. SEWARD, '06S

IN every industry there comes a time when a more of less radical change takes place because of the introduction of new machinery or processes resulting from some important inventions. Sometimes this change has amounted to a so-called "Industrial Revolution" because of the violence of the forces at work. These forces may affect the whole social structure and well-being of the population of an entire nation, as in the case of the invention of textile machinery and of the steam engine in England just after 1750, or the invention of the cotton gin and the development of coal mining machinery in this country. The general character of these inventions and the tendencies developing immediately after their introduction are always such as to make it possible for the less skilful people to participate in greater numbers in production and still do better work with more consistent accuracy at reduced cost. The former skilled artisans must advance in the indistrial scale and build the tools needed by the less skilful men or else fall out of line. Those who advance are receiving higher wages and those less skilful persons who are admitted to a larger participation in production because of the transfer of skill which has occurred are greatly benefitted until we reach a stage of mass production which is dependent on mass purchasing power and they become subject to the dangers of over-specialization. Machinery or processes are then slowly improved by the process of re-design and application until a period of comparative quiet is established, which may last for a generation or so and possess considerable inertia. Suddenly an important invention or development is made, and the cycle begins again, leaving obsolescence in its wake.

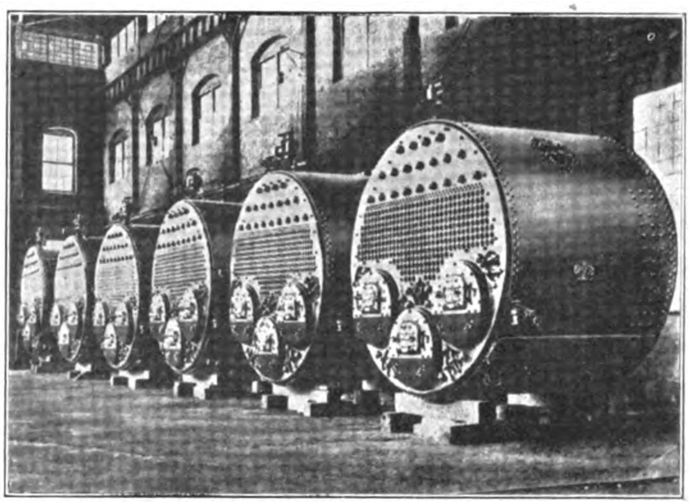


Fig. 1. Battery of Six Scotch Type Marine Boilers—Three-Furnace, Common Combustion Chamber.

Transportation as an industry has not been subjected as much to the violence of cycles of development as to the frequency of their occurrence. This is especially true of water-borne commerce.

It is the task of the marine engineer to provide a means of propulsion for ships which has the greatest possible dependability, economy, safety and ability to meet the exacting demands of service. He must also provide auxiliary equipment for the various hotel-like services demanded for travellers and crew. The operation and adjustment of all apparatus must not be so complicated as to be beyond the powers of the available personnel. The average American marine engineer is a very resourceful individual but he cannot be expected to produce ton-miles at sea with unproved apparatus. In general we do not train our industrial operatives very well and the marine engineering trade is no exception. The difference is that in the shops ashore there is help available while at sea the vessel simply must "mote" somehow. This accounts for the more conservative attitude always taken by marine engineers as compared with power plant practices ashore.

The present time is a most interesting period in marine engineering and it is not difficult to see that the applications now being made of inventions and improved design in this field are producing radical changes in our procedure, although the results are not violent enough to be called revolutionary. We have several methods of doing the same thing, with more to come, and are striving to find the "one best way" by observing the performance and cost of these several methods in actual service. We are gradually evolving a logical field of application for the various types of equipment, but there is considerable and vigorous discussion ahead of us throughout this experience.

Scotch Boilers and Reciprocating Steam Engines.

For many years the standard marine power plant included coal-burning Scotch boilers and reciprocating steam engines. We produced a fine type of engineer who thoroughly understood their operation and maintenance. We could get a husky type of individual for the laborious job of stoking and cleaning fires and another for the routine oiling and keying up of the engines. An engineer served a real apprenticeship and knew his job when he lived through this experience.

The Scotch boiler, such as shown in Fig .1, is today a very economical unit (except for its great weight) and has always had the advantage that it could endure operation by rather unskilful personnel. It held a large body of water, did not require precise water tending, was internally fired and delivered the steam even when badly neglected. The reciprocating steam engine is a costly construction today but if carefully built with short ports and close clearances can be very economically operated. We have a fine body of men who thoroughly understand the operation and adjustment of this wonderful and beautiful mechanism. It is composed, however, of many moving parts and requires much high grade payroll to build it.

Direct Turbine Drive.

Mechanically we prefer to substitute a continuous rotary motion for a reciprocating motion and so we observe the turbine making its way in the marine field. As there were no reduction gears, the turbines were first direct-connected to the propeller shafts. One of the plants still in good operation today is on the S. S. Olympic. Its arrangement has a long space occupied by Scotch boilers, aft of which are the reciprocating engines and a low pressure turbine. The ship has three propellers, the wing propellers being driven by reciprocating engines and the center propeller by the low pressure turbine. In maneuvering, before dropping the pilot, the wing screws only are used with the steam exhausting to condensers. After settling down on the long course, the low pressure turbine is cut in and there is a further expansion of the steam in a cruising combination of the equipment.

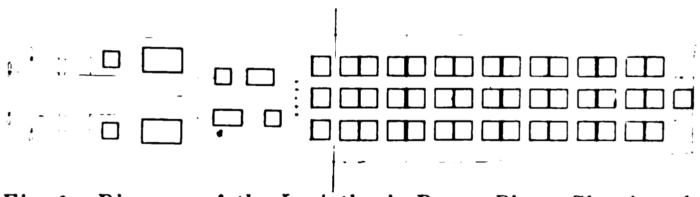


Fig. 2. Diagram of the Leviathan's Power Plant, Showing the Arrangement of Her 46 Boilers and 8 Parsons Type Turbines.

Further applications of the direct turbine drive principle were made about 1910 when the present Leviathan was designed. Fig. 2 shows diagrammatically her 46 boilers arranged in four boiler rooms and the eight Parsons type turbines. For maneuvering purposes the steam may be expanded through two turbines on each side so that either port or starboard pair of propellers may be driven ahead or astern. The astern turbines are in entirely separate casings and can produce about 60 per cent as much power as the go-ahead units. For the cruising combination, the go-ahead turbines are arranged as a four-cylinder triple-expansion plant, the high pressure being on No. 3 shaft, intermediate pressure on No. 2 shaft and two low pressure turbines on the wing shafts (Nos. 1 and 4). The boilers are Yarrow water-tube express type not unlike that shown in Fig. 3 for our present-day design of steam plant, as indicated by the titles. The Leviathan design was used in several large plants, but it is a compromise design and will not be used in any new plants today. At the normal full-power speed of 180 r. p. m. the turbines are turning too slowly for best efficiency, in spite of their great diameter, while it would be desirable for the propellers to turn at a slower rate. The introduction of reduction gears and the electric drive have overcome this difficulty.

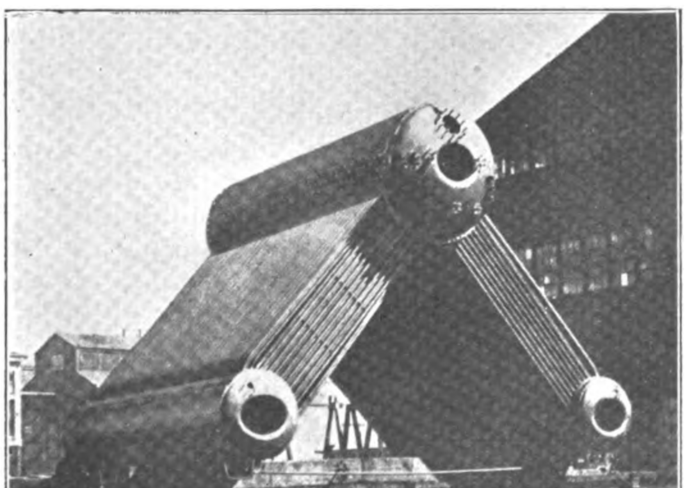


Fig. 3. Yarrow Type Boiler, without Casing, for the U. S. S. Omaha.

Oil Burning Boilers and Mechanical Reduction Gears.
American Marine Boiler B & W Type.

The typical American marine boiler is the B & W Type, shown in Fig 4, as used on the new S. S. Malolo. With the introduction of fuel oil we have developed the applications of the principle of the transfer of skill so that a frail youth may now regulate the flow of air and oil spray to produce steady, efficient combustion, in marked contrast to the intermittent coal firing of his husky predecessor. The oil may be stowed in the double bottoms and other places not adapted for coal bunkers. The oil costs more per ton but we have cut our payroll in the fire room to about one-third of its value when burning coal. The Navy has given us valuable leadership in developing the oil-burning plant.

From the World War there came some good designs of merchant ships designed by American engineers. The ships' plants combine oil-burning turbines with mechanical reduction gears.

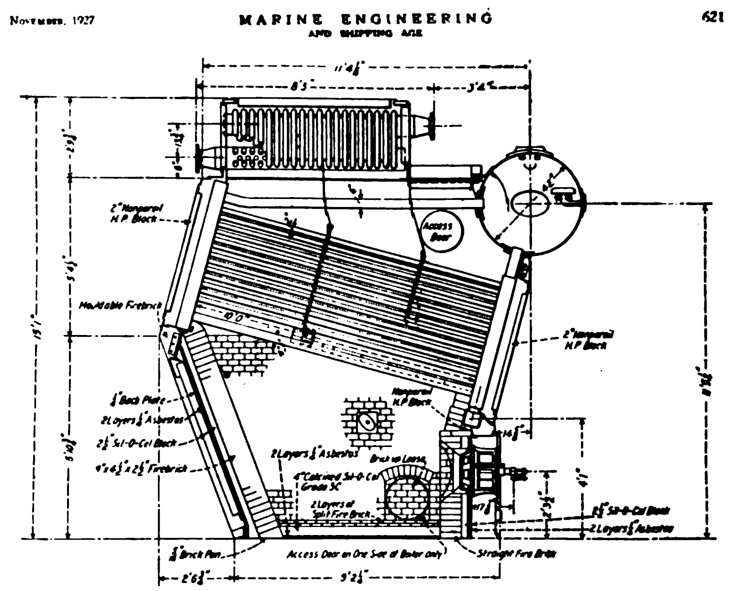


Fig. 4. Cross Section of Boiler: Steam Pressure, 280 Pounds per Square Inch; Superheat, 100 Degrees F.

Very efficient mechanical reduction gears are now in use in most of our turbine-driven merchant vessels. Their design has been rapidly evolved and not without overcoming many inherent difficulties. In general they are of the double spiral or herring-bone type, with very carefully cut teeth, with an oil spray at the point of contact between pinion and gear, with one plane or two plane, single or double reduction in speed and having a Kingsbury thrust bearing incorporated in the design of the gear case at the end of the main shaft. In a few years we shall know what to expect as a useful life of such gears with correct upkeep. (See Fig. 7.)

One of our most recent American designed and built ships is the S. S. Malolo, (Fig. 5), equipped with 12 B. & W oil-burning boilers in two water-tight boiler rooms, and twin screw shafts each having two large gears on each shaft. Four turbines drive each shaft and the two engine rooms are divided by an ingeniously arranged bulkhead that places duplicate auxiliary equipment in each engine room. Careful studies were made of the stability of this ship as it might be affected by the arrangement

of water-tight bulkheads as shown in Fig 6. The Titanic disaster taught us that longitudinal bulkheads are not desirable. During the builders' trials of the Malolo a collision with a foreign freighter occurred in a fog, with the result that both boiler rooms

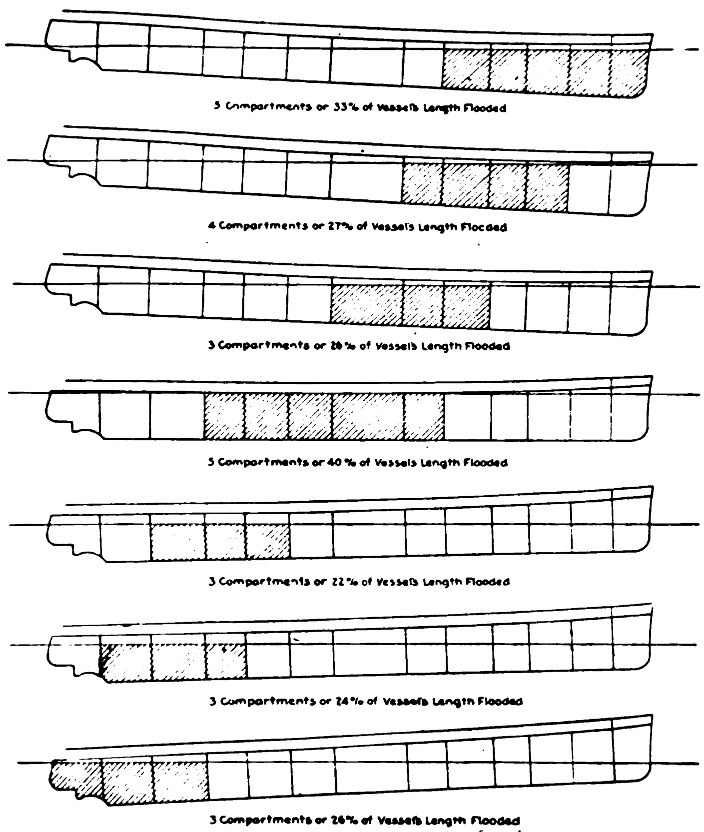


Fig. 6. Flooding Diagrams of the Malolo, Showing Change in the Trim of the Ship with Various Compartments Flooded.

were flooded. The point of collision was at the bulkhead between the two boiler rooms and while this was a most unfortunate accident in many ways, it did demonstrate that ships can now be designed to stay afloat when most seriously punctured. Fig. 7 shows a reduction gear installed on the Malolo.

Pulverized Coal.

The cost of oil is mounting and we have naturally turned our attention to the use of pulverized coal. The United States Shipping Board has equipped the S. S. Mercer, a 9000-ton freighter with apparatus which received ordinary bituminous bunker coal at any port and pulverizes it to the finest possible powder, which is blown into the furnaces of the Scotch boilers shown in Fig. 8. The fuel burns much as does a gas flame. Wonderful results in economy and maneuverability have been secured on this vessel and it marked the beginning of a new era in marine fuel engineering when this vessel made a round trip from New York to Rotterdam, fully loaded, through heavy weather, with no serious difficulties and with great saving in fuel cost. Powdered coal furnaces ashore have been very successful because of the space available to secure the correct heat liberation per cubic foot, but it is a different matter to accomplish this successfully in the limited space offered by the furnaces of

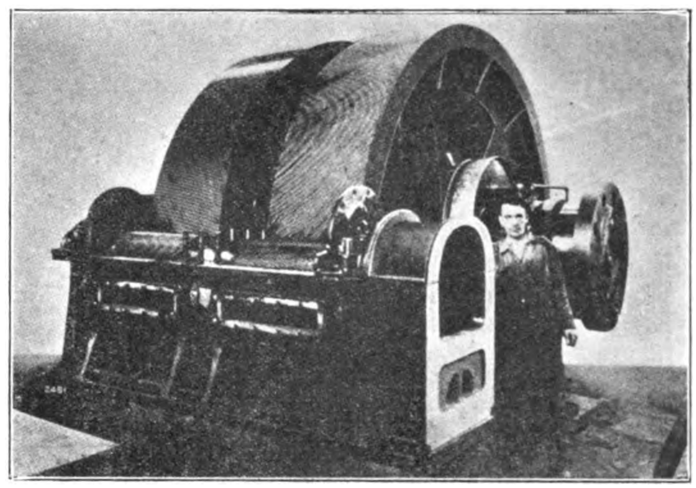


Fig. 7. De Laval Turbine Reduction Gear with Cover Removed.

a Scotch marine boiler. Before the equipment was installed on the Mercer, a long series of tests were conducted at the Philadelphia Navy Yard on a Scotch marine boiler. This boiler had been tested with many types of oil burners and the comparative efficiencies are plotted in Fig. 9. After the approved design had been erected, a 10-day continuous run at progressively heavier loads was run with the efficiency record of Fig. 10.

Important developments are expected soon in the field of higher steam pressures. We have improved our condensers and vacuum apparatus to such an extent that we must now look to the other end of the heat range and elevate our heat as far as possible before allowing it to do useful work. The use of higher pressures will result in smaller boilers which will not cost much more than our present boilers but it is doubtful if it will be expedient to exceed 600 lb. pressure with our present materials.

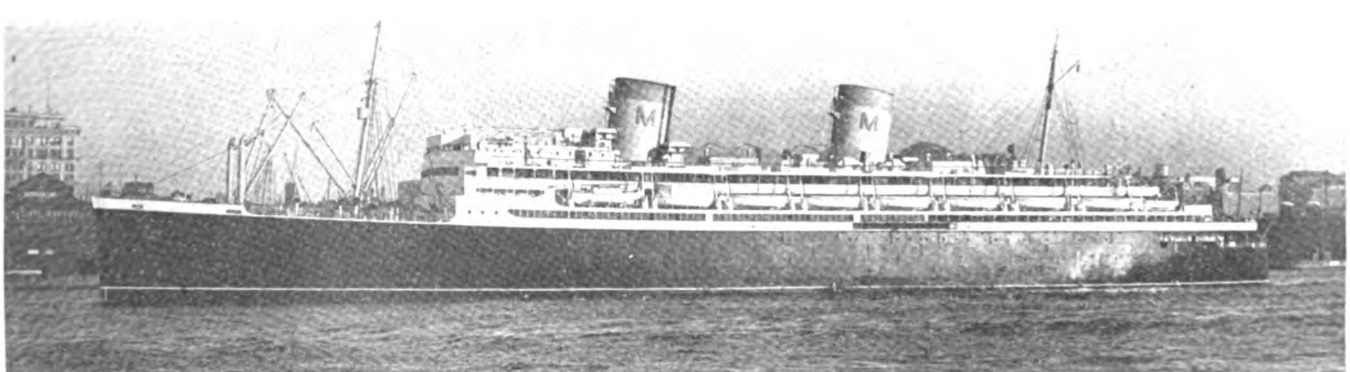


Fig. 5. New Matson Liner Malolo in the North River, New York, After Trial.

The New Electric Drive.

This article is being written just as the builders' trials of the new electric drive Panama Pacific Liner California are being very successfully completed. Equipped with 12 B & W oil-burning boilers, two 7000 KVA turbo-alternators (which are very similar to power house units ashore) and two large synchronous motors on the propeller shaft, this vessel promises to make history as the first electric drive passenger ship. The Navy has used this system with much success on the last six new battleships and on the two 180,000 hp. airplane carriers. Propulsive transmission efficiency at a high value is promised by the builders of the S. S. California, but it remains for the operators to maintain careful records of her operation for the next few years in orderto determine this point. There is every reason for the Navy to use electric drive, but in the merchant marine we must determine if the

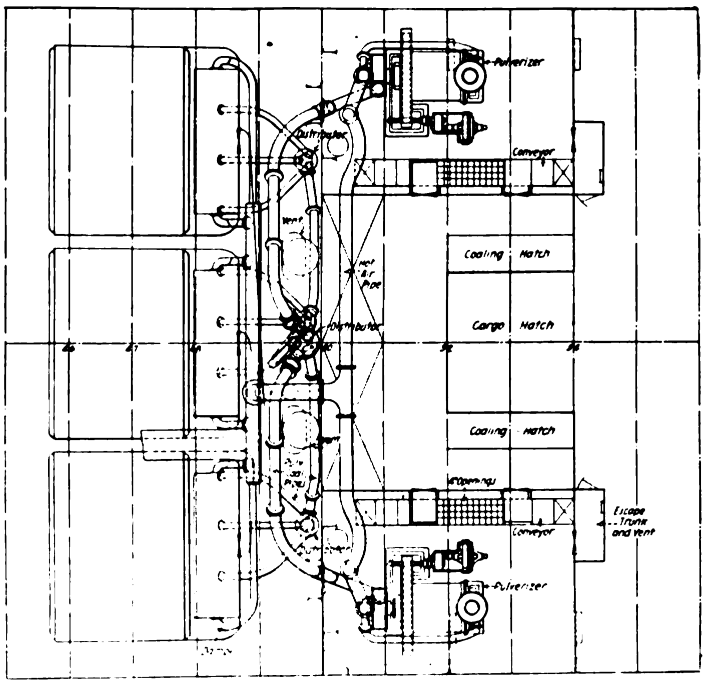


Fig. 8. Plan of Boiler Room and Bunkers Installed on the S. S Mercer, Showing Location of Pulverizers and Coal Conveyors and Arrangement of Piping and Distributors.

higher initial cost is justified by lower operating costs over a longer life than we are securing with turbines and mechanical reduction gearing. On the California there is ample space around all main and auxiliary power units, which makes for nice operation and adjustment; almost all moving machinery is driven by electric motors which make a precise adjustment possible for the most economical rates of speed; the whole design of this largest and newest product of American shipyards is a great credit to American design, ability and good taste in the passenber spaces.

Diesel Engines and Their Applications.

Diesel engines and their applications to marine propulsion are responsible for some of the warmest controversies in the engineering world today. The United States Shipping Board is investing its Dieselization Fund of $25,000,000 in such a way as to determine the characteristics of this form of drive. Fourteen ships built during the World War have had their boilers, turbines and gears or engines removed and various forms of direct Diesel drive have been substituted. There is no doubt as to the saving in space, the higher first cost, the remarkable saving in fuel, but we must work out this problem in terms of total cost, upkeep, reliability and service. Some of these plants are four cylinder, some six cylinder, single-acting, double-acting, four cycle, two cycle, but all are direct-connected, direct reversing engines. It is necessary to place these ships on long runs with a quick turnaround, such as the 39-day run to Australia from New York, because of the high value of the capital charges. Three more ships will be fitted with a Diesel electric drive. This form of drive, with pilot house control, has proved itself very well indeed for tugs, yachts, shifting boats and ferries.

Navigation Aids.

Space does not permit a discussion of the most interesting devices which are now being developed in order to make navigation

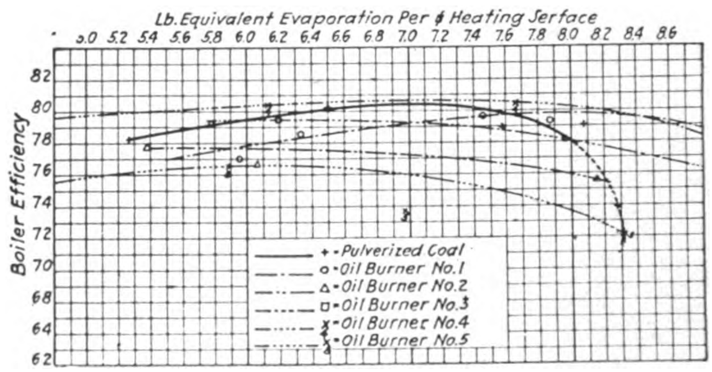


Fig. 9. Comparative performance of pulverized coal and fuel oil.

safer. Almost every ship has its radio for communication, but the use of the radio for giving compass bearings from shore stations is a great help to the navigator in bad weather. The fathometer, which gives an instantaneous reading of the depth of water under the ship by measuring the time of reflection of sound waves emitted from the apparatus on the ship, has been used on a destroyer steaming at full speed across the Atlantic Ocean and the resulting profile of the bottom agreed thoroughly with a record obtained many years before by the laborious process of sounding weights and lead line. The gyroscope has found several valuable applications, chief of which is the gyro-compass, which gives an indication, wherever desired on the ship, of the true heading in terms of true course, not affected by variation and deviation as in the magnetic compass. On the bridge we also meet "Metal Mike", the mechanical quartermaster, or gyropilot, who steers an unfaltering fine course, when once put on it, with uncanny accuracy. We are beginning to realize the losses in speed which result from poor manual steering; losses which we

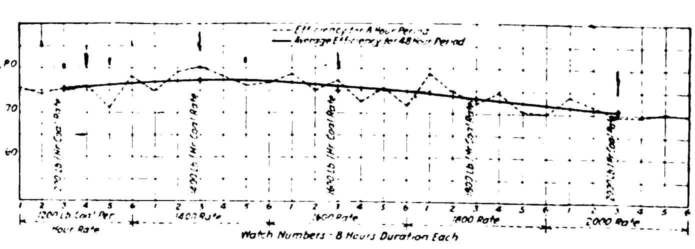


Fig. 10. Graphic Log of Efficiencies Obtained on Each of the 8-hour Watches of the 240-hour Test.

can now accurately measure in an electric drive ship with its various ammeters, wattmeters, and speed indicators on the propeller shafts. In the Navy the gyro has found many other important applications in the mathematical records and indicators necessary in gun-fire control. The gyro-stabilizer which quenches the rolling of a ship hundreds of times its own mass is another interesting development. By reversing the connec-

(*Continued on page 40*)

Important Discoveries in Glacial Geology

Past and Present Work in the Interpretation of the Latest Stage of Geologic History Gives Some Important Results

Prof. RICHARD F. FLINT

"THERE is one circumstance connected with the earth's surface which has not, that I am aware of, been noticed by any writer on Geology. The surface of every portion of the mass of rock, composing the nucleus of the earth, and which has not been exposed to the action of the atmosphere, is found worn quite smooth, and this equally, whether the covering of the earth be shallow or deep, of whatever species of rock the mass may consist, or however unequal and irregular may be the form which it has assumed. The common appearance of the surface is highly artificial, as if worn down by some powerful but not very delicate agent. The harder parts have in some instances, especially when forming veins in a softer stratum, the *feeling* of being polished, but the general character of the surface, although smooth to the eye, is somewhat rough to the touch, with slight grooves or channels, running in a uniform direction, very nearly north and south. . . ."

Thus runs part of a letter written in 1826 by a highly observant writer, to Benjamin Silliman, then Professor of Geology at Yale, one of the greatest geologists of his time. The writer probably lived in New England and had made his observations near home. Certainly if he had traveled far south of New York he would have revised his statement and made it less sweeping. For this "highly artificial" surface, covered with smoothed and scratched pebbles and boulders of all descriptions mixed into the soil, is not universal, but stretches from side to side of North America, occupying the entire area north of New Jersey, southern Pennsylvania, the Ohio River, the Missouri River, the northern Rocky Mountains, and the Oregon coast. It forms a landscape of smoothed hills, broad terraced valleys, extensive undulating plains, and in the far west, steep jagged mountains, contrasting strikingly with the landscape of the southern United States. Until about ninety years ago this thick mantle of heterogeneous material found lying upon smoothed rock surfaces in Europe as well as in America, was attributed to the flood of Noah or to a similar gigantic debacle; not until Louis Agassiz made the startling announcement that during a period not greatly antedating the present, ice had formed and had spread southward over both Europe and America, plucking out blocks and fragments of the solid rocks, crushing and grinding them to small bits, and depositing them extravagantly over the surface, were the older beliefs slowly upset. Since the time of Agassiz, geologists have been steadily at work in the glaciated areas of the world, especially in Europe and North America, studying this heterogeneous mantle, the "glacial drift", examining, sorting, measuring, comparing. They have done their work in valley sides, along lake shores, in road and railroad cuts and gravel pits—in every place where the structure and composition of the drift could be examined. And they have yearly discovered new and interesting things. For example, certain of these exposures in the region south of the Great Lakes show this arrangement, in nearly horizontal layers:

Fig. 1. "Highly Artificial." A Polished and Scratched Bedrock Surface Overlain by Glacial Debris. On the Outskirts of Norwich, Conn.

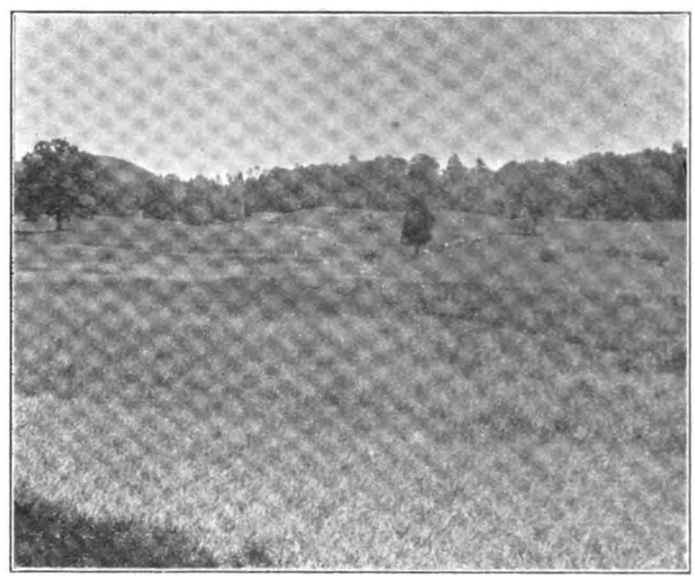


Fig. 2 Line of Hummocks Formed at the Margin of the Ice Sheet Near Somers, Conn.

4. Weathered drift with black plant matter.
3. Unweathered drift.
2. Weathered drift with black plant matter.
1. Unweathered drift.

Such a grouping is read and interpreted by the geologist thus: An ice sheet advanced slowly from the north, depositing a layer of drift. Conditions in the locality of the exposure were very cold

and life was rare or absent. Then the glacier, attacked by the warm rays of the southern sun, began to melt. The mantle of drift was uncovered and exposed to the action of sun, rain, and frost. The component pebbles began to disintegrate and decompose—to be "weathered". Plant life slowly crept northward, sent its roots into the weathered drift, and added humus to the soil as it decayed each year. After a lapse of time, the ice again descended from the north, destroying life and covering the surface of the older drift with a fresh new layer of glacial material. Again it slowly retreated, followed by weathering and reoccupation by plants. This very definite story was made more definite by the later discovery that the boulders and pebbles in

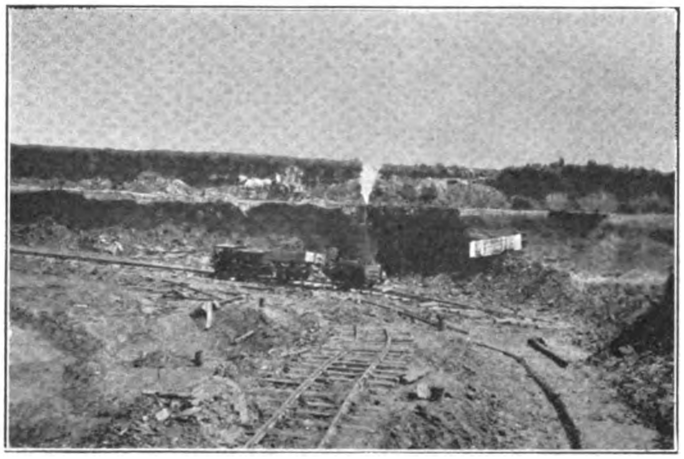


Fig. 3. Where the Banded Clays are Exposed to View. Pit of the North Haven Brick Company, North Haven, Conn., Showing Excavations in the Old Lake Bed, the Surface of Which Appears above the Wagon. Photo by G. T. Wickwire

the lower sheet of drift (No. 1) consist of different kinds of rock from the material which compose the upper sheet (No. 3). This at once led to the suspicion that the two advances of the ice had come from entirely different regions. This theory was borne out by the discovery that the material of the lower drift matched up with the bedrock in eastern Canada, while that of the higher sheet was identical with the rock masses between Lake Superior and Hudson Bay. Careful comparison of many sections has revealed the fact that at least four such separate advances of the ice took place, and it is even possible that there were as many as five. The region south of the Great Lakes is the finest area in the world for the study of such sections.

The Ice Sheet in the United States.

In view of the great lateral spread of most ice-sheets, it is difficult to believe that there were several distinct glacial advances and retreats in the Middle West, while New England was icebound but once. Yet thus far we have no evidence that any ice sheet older than the latest one of the Middle West ever covered the northeastern United States. Occasionally, bits of evidence had been found, but none has proved conclusive. And geologists, with a moral conviction that real evidence exists if it can only be found, are still diligently searching.

But if we content ourselves with the study of the last ice sheet, we need not look for special exposures to read something of its history. Over on Long Island, a great range of low hummocky hills extends from end to end of the island—from Montauk on the east to Brooklyn on the west, and from Brooklyn it extends on across Staten Island, through New Jersey, Pennsylvania, Ohio, and far to the west. This represents the southernmost limit of advance of the last ice sheet—the marginal moraine or dump of debris of all kinds from upon, within, and under the ice mass as its front remained stationary for hundreds, perhaps thousands, of years. Whatever water melted from the ice during this time flowed southward, washing away parts of the moraine and depositing the debris out beyond the edge of the ice. In this way the great sloping plain which forms the southern or seaward margin of Long Island was built up. Eventually the ice did begin to retreat, and during this retreat a curious thing took place. The ice front halted at regular intervals and remained stationary for considerable periods of time. This is easily seen, once the meaning of the Long Island moraine is understood, in the diminutive lines of moraine which traverse Connecticut and Rhode Island from east to west. They are anything but straight, because nearly all the valleys of this region run north and south, affording alternate exposure and protection for the ice front. Long lobes of ice extended southward down the valleys, while melting took place rapidly on the intervening ridges. This is all depicted for us in the marginal moraines, which, always preserving for us records of the successive positions of the ice-edge, loop far southward in all the valleys and run back northward over the ridges. In many places of course parts of this gigantic and intricate script have been washed away by glacial waters; but enough remains so that the

Fig. 4. The Record of More than a Hundred Years of Ice-bound Time. Detail of Banded Clays in a Pit Near Hartford.

pattern of the whole can be easily restored. No fewer than fifteen separate lines of moraine extend across Connecticut, at equal distances from one another. Why did the melting ice front stop and stand still at such regular intervals? We know that retreat of an ice sheet is caused chiefly by melting, and that the rate of melting depends chiefly on the intensity of the sun's rays. We know further that the heat given off by the sun varies in cycles which appear to have lengths of about 1100 years. These cycles are known as sun-spot cycles because the sun-spots wax and then wane throughout the course of any one cycle. It seems altogether likely that such phenomena were responsible for this pulsatory behavior of the receding ice, although this idea is still only conjectural. Unfortunately we have no yardstick with which to measure the actual number of years which elapsed between any two successive halts of the ice front and in consequence the exact relation of the moraines to the sun's heat must be left to the future for determination.

Deposits Left by the Retreating Ice.

Just as in the case of the great halt on Long Island, water poured southward off the ice front at each stage of retreat, carrying sand and gravel and depositing these materials, as terraces and sand plains in the lowest available places, namely, the valley bottoms. This is the origin of nearly all the terraces, lake and valley-flats of southern New England, deposits which form the most important source of commercial sand and gravel. The city of New Haven is built on a flat sand plain of glacial origin.

Much has been learned by a study of the clays which were deposited in the deeper and quieter lakes south of the ice-front. Such lakes existed in the Hudson, Connecticut, Quinebaug, and other valleys. The drained lakes are worked today for valuable brick-clays, and in the cuts and pits made by many steam-shovels we find interesting things exposed. Wherever these clays appear, they are seen to be composed of very thin fine bands of alternating silt and fine clay.

Study of glacial lakes in northern latitudes where deposition is going on at the present time, shows that the period of greatest melting is in the spring. Freshets loaded with fine rock particles then rush out from the ice and find their way into the lake. The coarsest material, the silt, soon drops to the bottom, but the finest clay particles remain in suspension for months, settling during the fall and winter. Thus a pair of bands, consisting of a silty layer below and a clay layer above, represents a year's deposit in the lake. When hundreds or even thousands of these pairs of bands are now exposed in an old drained lake bed, it follows that by careful measurement we can discover approximately how many years were involved in the life of the lake. Each pair of bands has its own individual peculiarities of thickness and composition and frequently therefore a single pair may be recognized by an expert in wholly different exposures many miles apart. DeGeer of Stockholm, the originator of this method of measuring the banded clays, lays claim to having recognized in the glacial lakes of the Argentine the identical layers which he had previously studied in Sweden. That such a thing is really possible is not conceded by all geologists, but it is certain that in the Connecticut Valley between Springfield and Hartford there are the remains of an old lake in which more than a thousand pairs of bands have been recognized and measured. The topmost layers have been planed away by erosion, so that we cannot know how much longer than a thousand years the lake existed.

The Formation of New River Valleys.

There is an old saying that water seeks the shortest route to the sea, but to this statement the qualifying phrase should be added "when left to itself". When a great mass of ice creeps downward over a broad drainage area such as southern New England, it freezes up a good deal of the drainage it finds, and has things pretty much its own way. By the time great dumps of moraine have been scattered over the surface and the ice has melted away, the water from the melting ice and later from the local rainfall cannot always follow its old accustomed channels. Dams of drift—ice-carried débris—are everywhere, some old divides have been cut away, new lake basins have been scoured out, and in consequence the new streams wander about in an aimless fashion seeking a low but necessarily torturous route to the sea. Old abandoned gaps cut deep into hard rock long before the ice age began, today stand high and dry as witnesses to the large streams which formerly occupied them. Cooks Gap near New Britain and the Bolton Notch back of South Manchester are striking examples. Follow the course of the Farmington River southward through the highlands past New Hartford and Collinsville, see it emerge above Farmington into a broad valley, and then make a sharp hairpin bend turning straight north for twelve miles to Tariffville before it again winds southward to the Connecticut and the sea. Yet the divide which separates this stream system near the elbow, from the headwaters of the Quinnipiac, a much shorter route to the Sound, is only a little over ten feet

(Continued on page 40)

OUR CONTRIBUTORS

Herbert L. Seward, who discusses Marine Navigation, obtained his Ph.D. from Yale in 1906 and his M.E. in 1908, remaining as a member of the Faculty. At present he is Associate Professor of mechanical engineering in charge of industrial management. During the war he developed and operated the United States Navy Steam Engineering School at Stevens Institute.

Cassius A. Fisher, who writes on the oil production of Venezuela, is a member of the firm of Fisher & Lowrie, geologists and petroleum engineers, Denver, Col. He graduated from the University of Nebraska in 1888, received his B.A. there in 1900 and his Honorary D.Sc. in 1927. He was assistant instructor at Yale in 1902–03. Dr. Fisher is now carrying on geological exploration for petroleum in Northern Canada and South America, as well as investigations in the western part of the United States.

Richard F. Flint, who writes on Glacial Geology, graduated from the University of Chicago in 1922. In 1925 he received a Ph.D. from that university. He has been connected with the U. S. Geological Survey, the Missouri Bureau of Geology and Mines, and the Kentucky Geological Survey. He is an Instructor of Geology at Yale.

Harry A. Curtis writes on better utilization of coal. He holds from the University of Colorado the degrees of B.S. and M.A., and from the University of Wisconsin, the degree of Ph.D. He was Professor of Chemistry at the University of Colorado from 1914 to 1917. Later he taught Chemistry at Northwestern University. He has been at Yale since 1919.

Lester Clyde Lichty is Assistant Professor of Mechanical Engineering. He received his B.S. from the University of Nebraska in 1913, his M.S. from the University of Illinois in 1916, and his M.E. from Yale in 1925. Before coming to Yale he was Assistant Professor of Mechanical Engineering at the University of Oklahoma. During the war he served as First Lieutenant in the Air Service.

Venezuela Second in World Oil Production

Richness of Reserves, Accessibility to Markets and Fairness of Petroleum Laws: Factors in Rapid Rise of Republic in World Oil Affairs

C. A. Fisher

IN 1927, Venezuela rose from fourth to third place in annual output among the oil producing countries, and during the latter part of that year, its *rate of production* ranked second only to the United States, an event which, in its relation to the world oil situation, was of more than passing interest. Furthermore, it is increasing its output at the present time at a greater pace than any other oil producing country. Venezuela has registered each year since the end of 1917 an average increase in production of nearly 100%, and at present is producing at the rate of about 240,000 barrels per day, with many wells closed in and practically all choked down. The present potential production from wells already completed is variously estimated at from 400,000 to 500,000 barrels per day, and semi-proven reserves are now estimated at 1,000,000,000 barrels greater than they were a year ago. Results of this remarkable character have been obtained in spite of the fact that wildcatting has been practically negligible as compared with the extent of the potential oil area. The proportion of dry holes has been smaller than in any other virgin territory of comparable size, and extensive areas with favorable indications remain as yet unprospected.

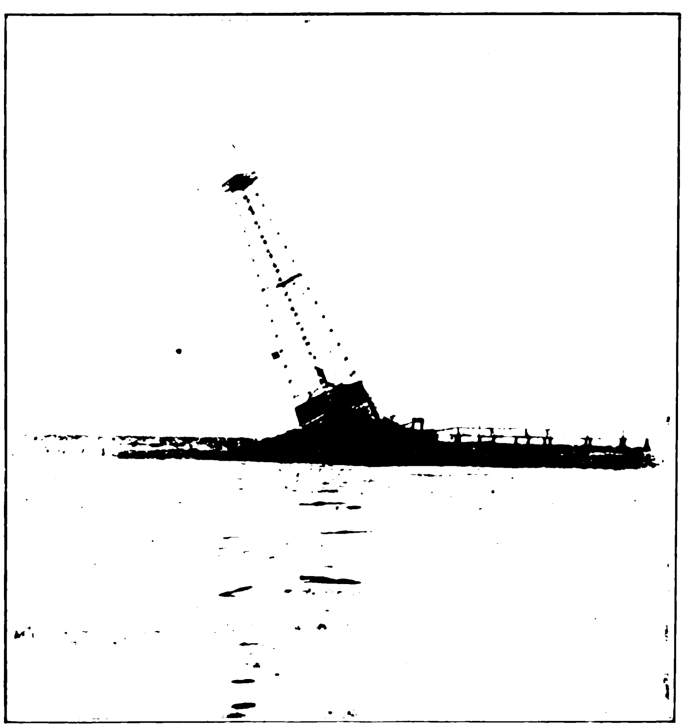


Fig. 1. La Rosa Well 444. Derrick Falling in Maracaibo Lake After Being Undermined by a Blowout of Oil.

Among the more important factors contributing to Venezuela's rise in prominence are the inherent richness and virgin character of its oil reserves, its relative accessibility to the larger refined and fuel oil markets, and the fairness and workability of its petroleum laws. Coming at a time when the oil industry of this country is feeling keenly the demoralizing effect of over-production, but hopeful of soon emerging from this situation, the rise in yield of Venezuelan fields is viewed by many operators prominent in the industry with a certain measure of apprehension. Such misgivings are well founded, for the possibilities of any change in the present oil situation are certain to have a close relationship with production and exports of South American countries. An examination of the records showing the movement of oil from South America to the United States in recent months certainly establishes that movement as a factor to be reckoned with in the present prospective oil situation.

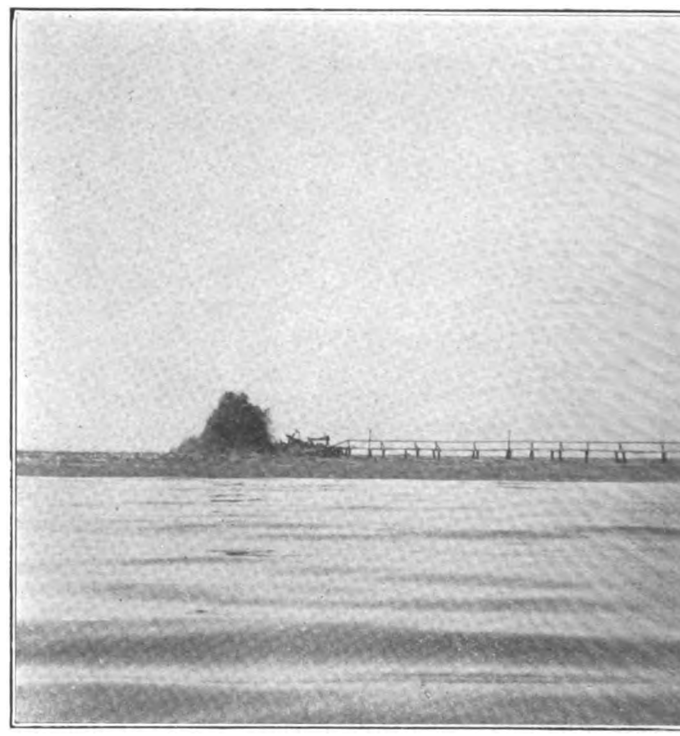
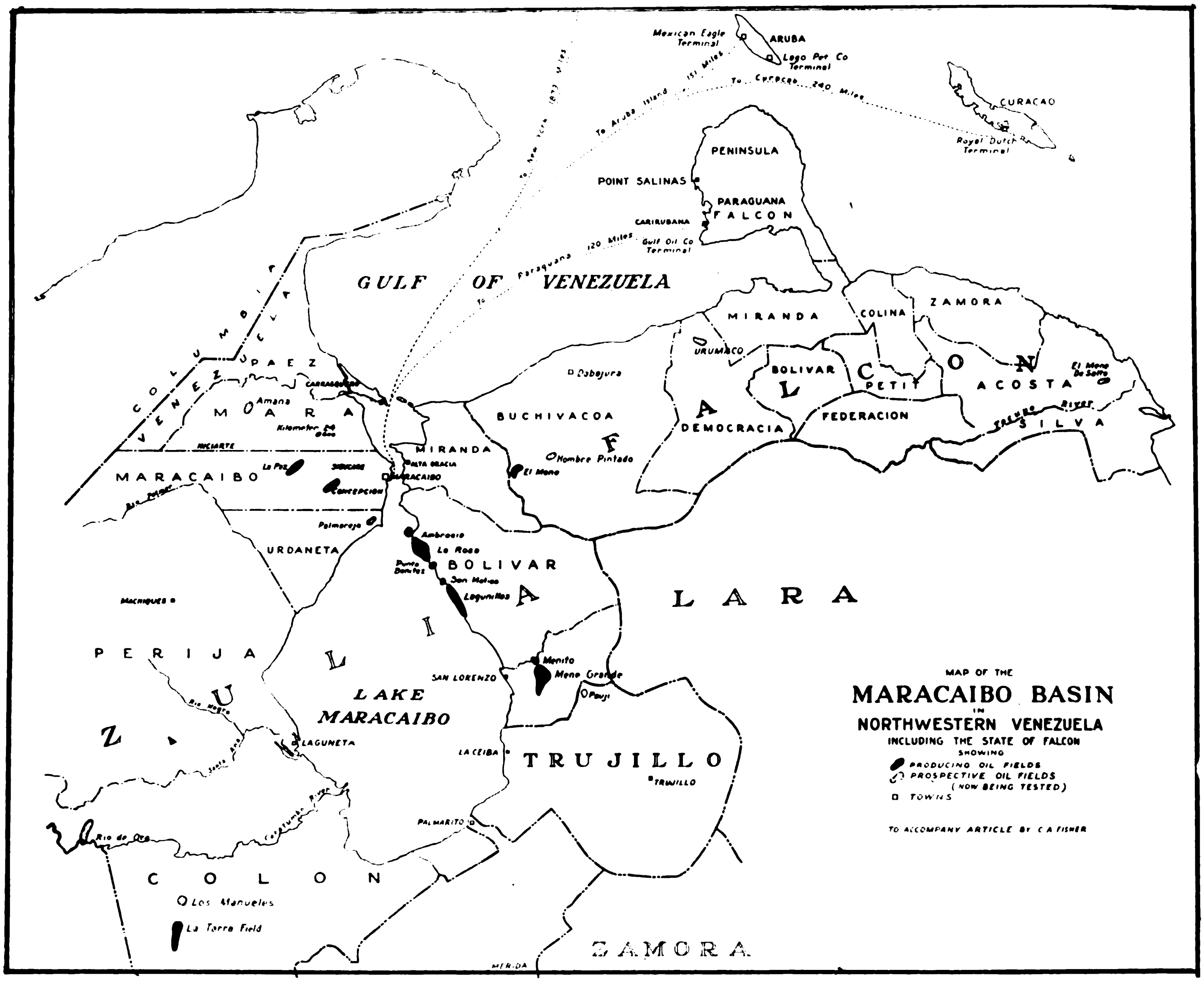


Fig. 2. La Rosa Well 444 View After Derrick Was Submerged Showing Gusher Rising Through 38 Feet of Water and 20 Feet into the Air.

While the evils of over-production in 1927 have been very great and far-reaching, and cooperation as a corrective measure is undoubtedly an urgent necessity, the fact still remains that our underground reserves of oil have been drawn on at a more rapid rate during the past year than ever before in the history of the industry. Periods of overproduction in the past have generally been of relatively short duration, scarcely continuing for more than a year without interruption by threatened shortage, while oil consumption has been progressing rapidly, almost without recession, for the past decade. One need only glance at a map showing the territory covered in the United States by oil development or exploration to become convinced that our oil resources are in an advanced state of exploitation, and if we view the question from a standpoint of conserving our own nation's petroleum reserves, an increase in the oil production of neighbor-



ing countries might be regarded as advantageous rather than menacing.

The rapid pace at which Venezuela has been gaining on Mexico in oil production during the past two years—due to a rapid increase by the former and a pronounced decline by the latter—has not passed unobserved by the industry, and therefore its ascendancy over Mexico in the latter part of 1927 did not come altogether as a surprise to those familiar with the situation. When it is considered that the real beginning of commercial production in Venezuela may be said to date no farther back than 1917, while in 1927, ten years later, it produced over 64,000,000 barrels, and at the close of last year had risen to second place among oil producing countries, it may be said that the rate of its development has been scarcely short of phenomenal.

Early History.

Little is known of the early history of the petroleum industry in Venezuela prior to 1884. Early explorers make casual reference in their reports to seepages of petroleum, and an occasional reference is found concerning local uses of oil by the natives prior to 1900. While the first oil concession was granted by Venezuela in 1884 to Compania Petrolera de Tachira on a small tract of land in the vicinity of San Cristobal (which company carried on operations in a small and primitive way) actual exploration in Venezuela did not begin until 1912, when British interests acquired by transfer certain concessions previously granted by the Venezuelan Government. The active exploration which began in 1912 proceeded slowly and was retarded more or less by the outbreak of the World War in 1914, the year when the Mene Grande field was discovered. During the period immediately following, the results were desultory, excepting at Mene Grande, where a large and important field was outlined.

Developments.

In December 1922 the Barroso No. 2 well in the La Rosa field came in, with an initial yield of over 100,000 barrels per day. During the first ten days this well is estimated to have produced upwards of a million barrels, when it became choked with sand and ceased flowing. This well not only encouraged development, but demonstrated the unusually prolific character of the oil-bearing formations of the Maracaibo Basin, and quickly focused attention on its oil possibilities. A few days after this unusual completion, the La Paz field was discovered in the District of Maracaibo, about 60 kilometers northwest of the La Rosa field, and one of its earlier wells is reported to have produced for the first 12 hours at the rate of 35,000 barrels per day. Thereafter, exploration for oil throughout the Maracaibo Basin progressed at an accelerated rate. At the close of 1923 over 100 wells had been drilled by six different companies operating in the Basin. Commercial production of petrol-

eum in Venezuela in 1917 was 120,000 barrels. In 1922, six years later, it had increased to 2,201,000. In 1924 the output amounted to 9,042,000 barrels. In 1925 it had increased to 19,687,000 barrels, and in 1927 to 64,400,000, the greatest in the history of Venezuela and nearly equalling all previous production, which amounted to 72,884,807 barrels.

The following table sets forth the annual rate of increase in production of oil in Venezuela from 1917 to and including 1927:

Yearly Production of Petroleum in Venezuela from 1917 to 1927 Inclusive.

Year	Production in Barrels
1917	120,000
1918	333,000
1919	425,000
1920	457,000
1921	1,433,000
1922	2,201,000
1923	4,201,000
1924	9,042,000
1925	19,687,000
1926	37,226,000
1927 (est.)	64,400,000
Total	139,525,000

It will be noted from the foregoing table that the average percentage increase in production for the last ten years has been almost 100%. A further measure of the rate of petroleum development in the Republic during the past year is indicated by the fact that of the total number of 797 producing wells, 291 were completed during 1927.

Producing Fields.

The Venezuelan oil fields may for convenience be grouped into three major provinces: The Maracaibo Basin and State of Falcon, commonly referred to as Northwestern Venezuela; the States of Monagas, Anzoategui and Delta Amacuro, comprising Eastern Venezuela, and portions of the States of Guarica, Zamora and Apure, in Central Venezuela. Production at present is confined mainly to the Maracaibo Basin and the State of Monagas. In Northwestern Venezuela there are 13 fields, 7 of which are producing, 2 temporarily closed and 4 fields proven but with no transportation outlet. There are 8 localities that have produced some oil but are not as yet entirely proven for commercial production. The 7 fields now producing and shipping oil, given in their order of importance, are Lagunillas, La Rosa, Mene Grande, Ambrosio, El Mene, Guanoco and Punta Benitez. Those temporarily shut down are La Paz and La Concepcion. Those fields already proven but without transportation outlets are La Tarra, Rio de Oro, Rio Palmar, Amana, in the Maracaibo Basin proper, and Hombre Pintado, Urumaco, Mene del Salto and Pozon in the State of Falcon. Among the localities that have already produced a certain amount of oil but are not yet proven commercial are El Tigre, Sibucara, Eastern Buchivacoa, Pauji, Menito, Mene de Lagunillas, Palmarejo and San Matias. Drilling is now active in scattered localities through Maracaibo Basin, especially near El Tigre in Mara, Palmarejo in Eastern Urdanete, Rio Palmar in Northwestern Perija, Rio Negro in Southeastern Perija, La Tara in Colon, Boscan in South Sucre, Buchivacoa in Western Falcon, Urumaco in North Central Falcon and along the Eastern shore of Lake Maracaibo from La Rosa to La Ceiba, as well as along the southern trend of the Mene Grande anticline.

Drilling development has recently connected the Ambrosio, La Rosa and Benitez fields into practically one continuous pool, and the recent discovery at San Matias is believed by some to indicate that continuous production may extend along the shore line of Lake Maracaibo from Ambrosio to Lagunillas, a distance of nearly 25 miles.

General Features.

The salient factor of Venezuelan oil fields, especially in the Maracaibo Basin, is the realization of all the requirements of oil pools, namely well developed sands suitable for reservoirs, associated with and overlying rich source shales and capped by impervious clays which prevent the escape of oil from reservoir traps. Formations of Cretaceous, Eocene and Miocene age all contain thick generating shales underlying sandstones and clays, and are strongly folded wherever exposed, producing many structures favorable for oil accumulation. The geologic similarity between the Maracaibo Basin and the California oil fields has been repeatedly pointed out, and in this analogy the writer is inclined to concur.

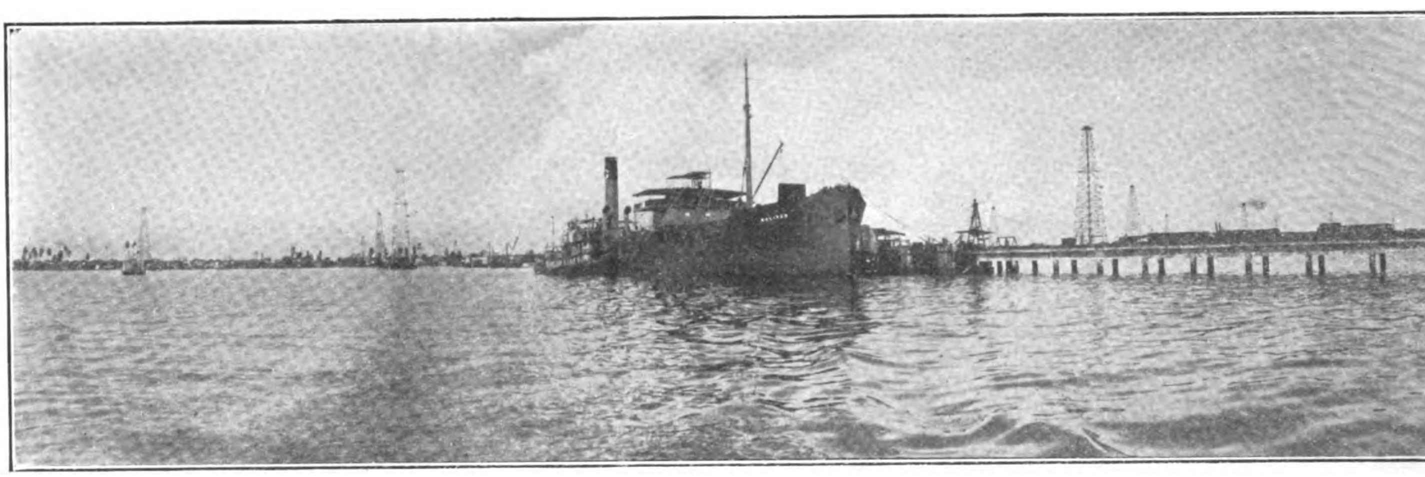


Fig. 3. Gulf Company Tanker Loading Oil at La Rosa Field, Maracaibo Lake, Venezuela.

Structures.

Generally speaking, the rocks of the Maracaibo Basin dip inward from the enclosing mountains toward the center of the basin. Conflicting major pressures occasioned by the development of the enclosing mountain uplifts have resulted in the formation of many secondary folds on the flanks of the basin proper. The secondary structures trend for the most part parallel to the nearest enclosing major uplift, but in one locality, the Macoa nose, cross folding occurs, probably due to faulting in the foothills to the northwest. The secondary folding results in asymmetrical anticlines with the steeper flank toward the lake and the synclinal basin. These anticlines are arranged generally

in echelon and adjacent to the mountains tend to be narrow, steep sided and faulted, while nearer the center of the basin more gentle dips and less faulting prevail.

Around the periphery of the basin the secondary folding is obvious and can be easily located and mapped. Nearer to the center of the basin, however, the prevalence of recent sedimentary deposits covering the surface, causes the location and mapping of structures to be more difficult and other methods such as pit-digging, diamond drill prospecting and the use of geophysical instruments are resorted to. By these various methods some of the larger structures have been delineated, also some of the major structural trends have been mapped. Sounding of the lake bottom has been undertaken to locate submerged ridges which may prove structural. (Plate 1 shows some of the larger structures and structural trends and their approximate location in the Maracaibo Basin.)

Seepages.

The richness of the formations in the Maracaibo Basin is evidenced by the abundance of seeps, saturated rocks and other surface manifestations of petroleum. Generally speaking, seeps of greater or less magnitude may be said to occur at frequent intervals along the outcrops of the formations underlying the Maracaibo Basin, from the District of Mara south and east to the District of Sucre. At Mene Grande, Inciarto, La Paz and El Mene, occur some of the largest seeps in the basin, comprising many acres in extent.

These phenomena have been responsible to date for the location of a majority of the present producing fields.

Gravity of Oil.

The quality of crude produced in Venezuela may be said to range from a heavy asphaltic oil having a gravity of from 17 to 25 degrees to the light paraffin base oils of from 27 to 42 degrees. The greater part of the oil is of the heavier variety. Mene Grande, La Rosa and Lagunillas, comprise the heavy oil producing fields, while the lighter gravity oils are obtained from El Mene, Concepcion and La Paz fields, also in the newly discovered pools in the states of Mara and Falcon.

Transportation.

Excepting about 1,800 barrels daily from the vicinity of Orinoco Lake, the entire output of Venezuela oil is obtained from the fields in the Maracaibo Basin. The oils here are carried by pipe lines to the shore of Lake Maracaibo, where they are transported in specially constructed lake tankers to terminals on the Dutch islands of Curacao and Aruba and on the peninsula of Paraguana, for refining or transshipment to ocean-going tankers. The shallow bar at the mouth of the lake prevents the passage of ships of over 11½ feet draft. Owing to the above conditions, it is obvious that the output of Lake Maracaibo district is governed by the number of lake tankers available. This condition will continue until pipe lines leading to deep water terminals have been constructed, which do not exist at the present time. At the close of 1927, 58 lake tankers were completed and in service, aggregating in capacity from 5,000 to 17,000 barrels. These ships were operated by three companies, namely, the Caribbean Petroleum, Lago and Venezuela Gulf companies. The total present tanker capacity is around 210,000 bbls. a day. There are at present 13 lake tankers under construction, all of which will be completed by September of 1928. Plans are also under way for the construction of larger tankers capable of carrying upwards of 19,000 bbls. Pipe lines delivering oil to the lake are confined to Mene Grande, El Mene and La Paz and Concepcion fields, the total length of such pipe line construction being about 72 miles.

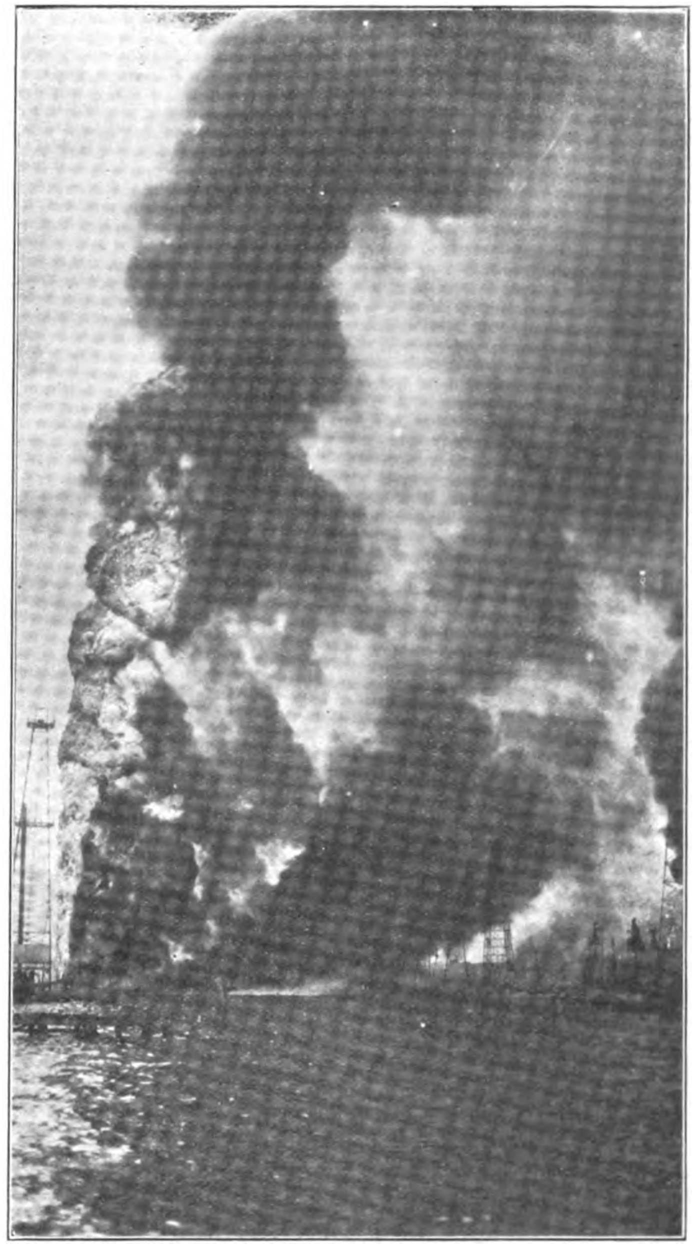


Fig. 4. Burning Oil Gusher, La Rosa Field, Lake Maracaibo.

Accessibility.

Venezuela's advantageous location with respect to the refineries on the eastern seaboard and bunker oil stations of the Panama Canal, has long been recognized by engineers familiar with the oil possibilities of this country. In fact, it has been repeatedly pointed out that oil companies can deliver Maracaibo oil to New York in less time than from Port Arthur or Tampico. Maracaibo is 40 miles nearer than Galveston to New York, 102 miles nearer than Tampico and about 3,000 miles nearer than oil ports on the Pacific Coast. Eighteen days is required for an ocean tanker to make a round trip from Maracaibo to New York. It requires over twice as long for an ocean-going tanker to make the round trip from Los Angeles to New York. In fact Venezuela oil has an advantage of over 50 cents in the eastern markets over oil produced in California or midcontinent.

Stability of Government.

Under the present administration which has been in existence since 1908, the country has prospered, the national debt has been reduced materially, and a substantial treasury surplus accumulated. A favorable trade balance is enjoyed at the present time.

(Continued on page 37)

Better Utilization of Coal Being Attained

Study of Microscopic Structure and Chemical Composition has Resulted in Development of Better Processes of Combustion and Coking

Prof. Harry A. Curtis

SINCE coal measures are so widely scattered over the earth, and outcrops of coal so common, it appears probable that the material we now call "coal" was known and various of its properties observed many centuries before it came to play any large part in civilization. The use of coal as a fuel was certainly known to the early Greeks; the Romans in Britain used coal from various outcropping seams; in the ninth century the Abbot of Peterborough leased certain lands with a requirement that twelve loads of coal be sent yearly to the Monastery; in 1306 Edward I prohibited the burning of coal in London, in an effort at solving the smoke problem which London, along with most other cities, has had on hand in all the centuries since.

We may say, then, that we have had several centuries of experience in burning raw coal. It is therefore with some degree of chagrin we must admit that even today wasteful methods prevail, and that our industrial cities are under a pall of soot-ladened atmosphere. Yet we may not overlook the very great improvements which have been made in the art of burning coal as a fuel. Mechanical stokers, chain grates, better design of furnaces, better control of combustion conditions, powdered fuel —all these have served to raise the efficiency of coal fired furnaces to a high level in the larger installations. It is in the smaller industrial furnaces, in domestic heating units, and in the railway locomotive, that better combustion conditions must be established if we are to have less smoke overhead. Obviously there are at least two lines along which improvements may come; first, if raw coal is to be the fuel, the development of small units for burning coal with an efficiency such as now obtained in the larger installations. As examples of this line of development we may mention various trials now under way with small machines which powder coal at the furnace mouth and blow the powdered fuel directly into the furnace. Whatever may be the success attained along these lines, it is evident that a second possibility of improvement, so far as the smoke nuisance is concerned, lies in so modifying coal ,by carbonization or other means, that smokeless combustion is obtained under all conditions. Nature has given us one coal which so burns, namely anthracite, but the supply is relatively small and limited to a very few localities, whereas smoky varieties of coal are abundant in quantity and widely scattered over the earth. One problem of surpassing importance now before the coal technologists of the world is the conversion of bituminous coal into a product as nearly like anthracite as possible, although most of us wouldn't mind if much of the ash were left out of the new anthracite.

We shall return later to a discussion of this problem.

Coal and Coke As Metallurgical Fuel.

Another of the great uses to which coal has been put is in the smelting of ores. The superiority of coke over raw coal for this purpose has lead to the development of our now enormous coke industry.

About 1621, Dud Dudley in England demonstrated that "pit-coal" or "seacoal" could replace charcoal in the smelting of iron. This discovery gave tremendous impetus to the iron industry of England for a time, but with Dudley's death the iron industry declined and the use of pitcoal for smelting was almost forgotten. In the years 1730–1735, however, the Abraham Darbys, father and son, revived the practice, and this marks the beginning of the reign of King Coal in industry. Two hundred years of experience has accumulated since then in the use of coal or coke as metallurgical fuel. Today one of our large coking plants making such fuel carbonizes over 30,000 tons of coal per day.

In view of the long period during which coal has been coked, and the tremendous size of modern installations, it is a bit of a shock to find that the coking process is not thoroughly understood. Even so seemingly simple a question as to whether the gas generated in the coke oven passes out mainly through the previously coked material or mainly through the yet uncoked coal in the center of the oven is still under discussion in technical journals.

When, however, we compare a battery of little old bee-hive ovens of a few decades ago with a modern byproduct coking plant, we must admit that progress has been made.

Coal As a Source of Fuel Gas.

In 1792 William Murdock began those remarkable demonstrations of the utility of coal gas in lighting house and factory which led to the rapid development of a coal gas industry in England. Our present coal gas industry has, therefore, about a century and a quarter of experience behind it. And here, as in the coke industry, we must recognize that progress has been great if we compare a modern city gas plant with the little old iron retort which Murdock set up in his back yard at Redruth over a hundred years ago.

When, however, we raise the question as to just wherein the improvements lie in gas making, in coke making, and even in burning raw coal, we realize that most of the improvements have been of a mechanical sort. Very few of them have in the past come from a better understanding of coal itself. Looking toward the future, it seems to us that a better knowledge of coal from the chemical standpoint, and a study of its behavior under carefully controlled but widely varied conditions is almost certain to yield results of considerable commercial significance.

Why Progress in Understanding the Nature of Coal Has Been Slow.

Anything in the way of a scientific knowledge of coal was out of the question in the early period of coal utilization. The microscope, in crude form, was, to be sure, available a hundred years ago, but such instruments were but little better than the unaided eye in giving information regarding the physical structure of coal. It has required modern instruments and the utmost refinements of modern technique to give us sure knowledge of the structure of coal. As for its chemical composition and constitution, be it remembered that the methods of analytical chemistry were crude and few in number a hundred years ago; that the structure of even simple organic compounds was unknown until about the middle of the last century; that most of what we call

physical chemistry has been worked out within the memory of the present generation of chemists.

Today, the analytical chemist has at his command methods of a degree of refinement which would have amazed chemists of much less than a hundred years ago. Organic chemistry since 1850 has so extended its scope that it takes volumes simply to list the substances which have been synthesized. Still more recently the methods and instruments of physics have been successfully applied in chemistry; in fact, the artificial borderline once set up between chemistry and physics has quite disappeared. The ultimate goal is perhaps that chemistry will be reduced to mathematical expressions.

Now with all the refinements of chemical methods, and all the background of chemical facts and theories, and all the improvements in old instruments and the development of new ones, it would seem that our knowledge of so important a substance as coal should be already considerable and growing rapidly. The fact is that only a beginning has been made in understanding coal from a chemical standpoint. One reason for this state of affairs is that relatively few investigators have undertaken research on coal since modern methods and instruments were available. But the main reason is that coal is a substance of high complexity from which solvents remove no more than a few per cent of the total, the soluble portion itself being highly complex. The action of chemical reagents on coal has so far given little information of significance. The destructive distillation of coal yields products which are so far removed from those of coal itself that knowledge of these products has not led to an understanding of the parent substance. We shall undertake, later in this paper, an outline of what chemical research on coal has actually revealed. Let us turn first to a short discussion of what the unaided eye and the eye aided by a microscope can discover regarding coal.

The Nature of Coal as Revealed to the Eye.

Casual examination of any small lump of bituminous coal, with the unaided eye, reveals that the lump is made up of numerous thin layers, and that there are at least three different kinds of material present, namely a jet black, glittering, seemingly homogeneous material alternating in thin layers with a dull black material obviously less homogeneous, while in very thin layers is a third component which looks much like charcoal, and which is, indeed, called "mineral charcoal" although, as a matter of fact, it is not charcoal at all and is only mineral in the sense that coal itself is mineral. The name "anthraxylon" has been given to the bright coal by the American investigator, Thiessen, and the name "attritus" to the dull coal. English investigators claim that there are two kinds of bright coal, which they call "clarain" and "vitrain"; the dull coal they call "durain" and the so-called "mineral charcoal" they have christened "fusain."

When the lump of coal was in place in the coal vein, the thin layers lay in the general plane of the vein, as would be guessed. If a face of the lump at right angles to the plane of the layer or vein be examined, the edges of the layers will appear as narrow bands running across the face of the lump. Thiessen believes that the bright black bands are the edges of small lenticular pieces of coal formed from what were originally small pieces of wood or woody material. The microscope shows that in many cases the woody structure is marvelously preserved.

Let us turn next to the dull layers of attritus or durain. A very moderate magnification (x 10) shows that the dull, durain bands are not homogeneous, but made up of thin strips of bright anthraxylon in a matrix of dull material. As higher and still higher magnification is used on the dull bands, an amazing array of plant structures in addition to the fine chips of anthraxylon or pure woody fiber is revealed. Spores, pollen, spore eximes, cuticle, resinous bodies, megaspores, and other plant structures mingle with a humic material, itself composed of more or less finely comminuted remains of plant structures. There has been preserved in coal a wealth of information regarding the plants from which the coal was formed, much more than was suspected before the modern technique of microscopy was applied to coal. The various steps by which vegetable matter became coal are not as yet clear, but we are beginning to glimpse them.

One more point we should perhaps mention before leaving this phase of our subject. The early microscopists who studied the constitution of coal were puzzled at the large proportion of spores, spore eximes, resinic bodies, etc., in coal as compared with the material presumably derived from the woody parts of plants. This may no doubt be explained by the fact that the spores, spore cases, pollen, resinic material, cuticle, are all more resistant to the chemical and bacteriological processes of decay going on at or near the surface of the peat bog in which the coal was formed. There would in this way be an enrichment of the coal substance in the more resistant structures. As a corollary to this view, it is to be expected that coal will not be as closely related to cellulose as would be the case if all parts of the original plants had been equally resistant to decay.

The Ash in Coal.

If all the combustible portions of coal be burned away there remains an inorganic ash. Only a small part of this ash was present in the plants which formed the coal. It is an incidental and accidental addition to the coal during the process of formation. Our chief interest in the ash today is how to get it out of the coal, and there are many so-called coal washeries in operation. Most of them depend on the fact that the ash in coal is usually not scattered uniformly through the coal but is segregated in layers much higher in ash and therefore heavier than neighboring layers of coal. The distribution of ash in coal is therefore a matter of considerable practical interest, and here it seems likely that X-ray examination of coal may be useful. The X-ray photographs are particularly interesting if taken with a stereoscopic camera and viewed in the usual stereoscope. The lump of coal with mineral particles distributed through it then looks just like a cake of ice in which opaque particles appear to be suspended.

Action of Chemical Solvents on Coal.

As mentioned above, there is no solvent which can, without question, be said to dissolve more than traces of material from bituminous coal. There are, however, a few solvents which seemingly accomplish a very mild depolymerization or incipient splitting up of some of the substances in coal to give soluble products. Of these solvents, three deserve mention, viz., pyridine, phenol, and benzene, the last named being used under pressure at temperatures much above its boiling point. Prof. Parr, President-elect of the American Chemical Society, has used phenol as a solvent in a number of his investigations, while Dr. Fischer of the Coal Research Institute at Mulheim has used benzene successfully. A number of English investigators, including Prof. Wheeler and his collaborators, have made rather extensive studies using pyridine and we shall mention their results particularly as being characteristic of those obtained in the field.

When a bituminous coal is extracted with pyridine, an amount of it goes into solution varying from one or two per cent up to, say, thirty per cent, depending on the kind of bituminous coal used. The pyridine may be removed from the extract by evaporation, although it has been found almost impossible to free the residue completely from pyridine, indicating, possibly, that

the pyridine is not strictly an inert solvent. If the dry extract be now treated with chloroform, a part of it goes again into solution. By means of two solvents, then, we may separate coal into three parts; the parts insoluble in pyridine have been called alpha-compounds; the parts extracted by pyridine but insoluble subsequently in chloroform, the beta-compounds; and the parts extracted by pyridine and subsequently soluble in chloroform, the gamma-compounds. Each of the ingredients of coal—vitrain, clarain, durain and fusain—contains all three of these alpha, beta, and gamma compounds, but not in the same proportions. At present a considerable amount of investigation is under way with the object of relating the alpha, beta, and gamma compounds to the behavior of coal under carbonization.

Differences in Coals as Revealed by Carbonization.

The destructive distillation of coal, such as accomplished in the ovens of a by-product coke plant or the retorts of a coal gas plant, is frequently called "carbonization." The course of events when coal is carbonized depends on a considerable number of factors. In the first place, the differences in various kinds of coals are most strikingly brought out during carbonization; indeed, it is quite posible to find two coals of identical proximate analyses but of widely different behavior on carbonization. These differences have long been recognized, and have been vaguely and loosely described in such terms as "coking coals", "caking coals", "swelling coals", "fat coals", "steam coals", "gas coals", "dry coals", "long flame coals". These are all but qualitative terms, indicating neither degree nor the conditions of observation. For scientific purposes the above terms are almost useless, and even for practical purposes it is becoming increasingly important to arive at more quantitative expressions.

The Coke-Forming Process.

Let us take a coal which, in the loose terms mentioned above, would be called a caking coal. When such a coal is carbonized, coke is formed. The first requirement in this process is that the coal must, at some temperature, partially fuse so that the individual particles of coal disappear and the whole mass becomes plastic. The temperature at which this so-called fusion occurs varies for different coals, but is usually in the range between 350° C. and 380°C. The coal is undergoing decomposition at this temperature and gas is being liberated. As the temperature is raised and the decomposition proceeds, there is a tendency for the liberated gas to puff and swell the fused coal. The plastic mass is filled with little bubbles of gas working their way out to free channels whence they can escape from the oven or retort. The decomposing coal is, however, becoming less and less plastic as volatile matter is liberated in gaseous form, and there presently comes a time when the mass becomes sufficiently rigid to prevent gas bubbles from moving through it. The bubbles are, so to speak, trapped in the coke, and from then on gas can escape from the inside of the bubbles or cells only by diffusing through the cell walls. In general, the sponginess of the coke so formed, and therefore its initial specific gravity, can be controlled by choosing the coals to be carbonized and by regulating the rate of heating. For metallurgical purposes, a certain degree of porosity is apparently necessary, or at least it is permissible. A typical lump of metallurgical coke will actually be found to have something like 45% of pores or free space in it.

When first formed the coke will be friable, even though it has no more than 45% of voids. Metallurgical coke, however, must be hard and strong. This is brought about by prolonged heating of the coke originally formed as the coal passed out of the plastic condition during carbonization. For most coals the plastic range is passed at a temperature of 430° C. to 450° C. As the temperature is raised beyond this point, the devolatilization process continues, but two other processes go on simultaneously and these are of greatest importance in making metallurgical coke. In the first place the true specific gravity of the coke material itself increases slowly, and secondly there is a shrinkage of the coke bulk, i. e., a decrease in the volume of the pores with concomitant increase in lump specific gravity. Both of these processes increase the strength of the coke.

The Reactivity of Coke.

As noted above, the coke which is first formed, at say 430° C., is a soft friable coke. The true specific gravity of the coke material itself, is in the neighborhood of 1.5, but the lump specific gravity will be less than unity due to the voids. Heating at higher temperatures slowly increases the true specific gravity of the coke to about 1.9 at 1100° C., and also shrinks the volume of the coke mass. This prolonged heating changes not only the physical properties of the coke, as expressed by specific gravity, crushing strength, etc., but it also changes the chemical characteristics of the coke. Particularly important in this respect is the fact that the temperature at which it begins to react with steam or oxygen, or carbon dioxide, is, in each case progressively increased as the temperature of the coking is increased. Here also there is needed a standard procedure for measuring the reactivity, and a quantitative method of expressing degree of reactivity.

Synthetic Anthracite.

We come back finally to the problem earlier mentioned, that of making an anthracite-like product from bituminous coal. It is here that knowledge of the kind we have been discussing, fundamental knowledge of just what happens as coal carbonizes, will point the way to success. This topic, of how to use the fundamental facts, is altogether too broad to be covered in the present paper. We shall content ourselves with discussing briefly the method used by one process which has been mentioned frequently in technical literature, limiting ourselves to an exposition of the process in the light of the fundamental principles above mentioned.

In this process, coal is carbonized in such a way as to remove the initial by-products from the retort without cracking them. There are many ways of doing this and the means used in the particular process chosen for discussion is of no particular significance. The yields of tar, gas, etc., and the character of these products, are about the same as from other low temperature processes. The coke is a very light, soft, and highly reactive material. It burns without smoke but otherwise it is a long way from being like anthracite.

We might pause here to remark that hundreds of inventors have erroneously assumed that, having rendered coal smokeless by a low temperature carbonization scheme, the problem of a smokeless domestic fuel was solved. As a matter of fact, this step is but the first and easiest one.

In the particular process we have elected to discuss, the coke is so soft that it could not be handled from plant to consumer's coal bin without excessive breakage into dust and other fines; it is so light and spongy that the consumer could not get his usual winter's supply in his bin, nor an over-night supply in his furnace; it is so reactive that the draft regulations of his furnace would not give adequate control of the fire. Obviously, such a fuel as this did not solve the problem. Now let us follow the process on through to its final product, interpreting the steps in terms of fundamentals. The lump specific gravity of the coke is, in this case, about .6. The true specific gravity of the coke substance itself is, as previously noted, about 1.5, and by

(*Continued on page 34*)

High Pressure Combustion Investigated

Series of Combustion Experiments in Mason Laboratory Have Led Scientists to Interesting Results on High Pressure Problems

Prof. L. C. Lichty

THE combustion process, in some form or other, has engaged the attention of man for a long time. In spite of this, the mechanism by means of which the energy of combustion is released remains practically unsolved.

Combustion is made use of to derive heat or to generate power, or both. In the early days the heating effect was the only interest had in combustion. In the last century however the generation of power by the combustion process has been extensively studied and developed.

Combustion at atmospheric pressure is going on continuously in modern steam-electric plants. In the average automobile traveling along the highway at a rate of 60 miles per hour the combustion process is occurring 20 to 25 times every second in each cylinder. The pressure of combustion in this case varies from 100 lb. to 500 lb. In the Diesel engine the combustion occurs at pressures under 1000 lb. per sq. in.

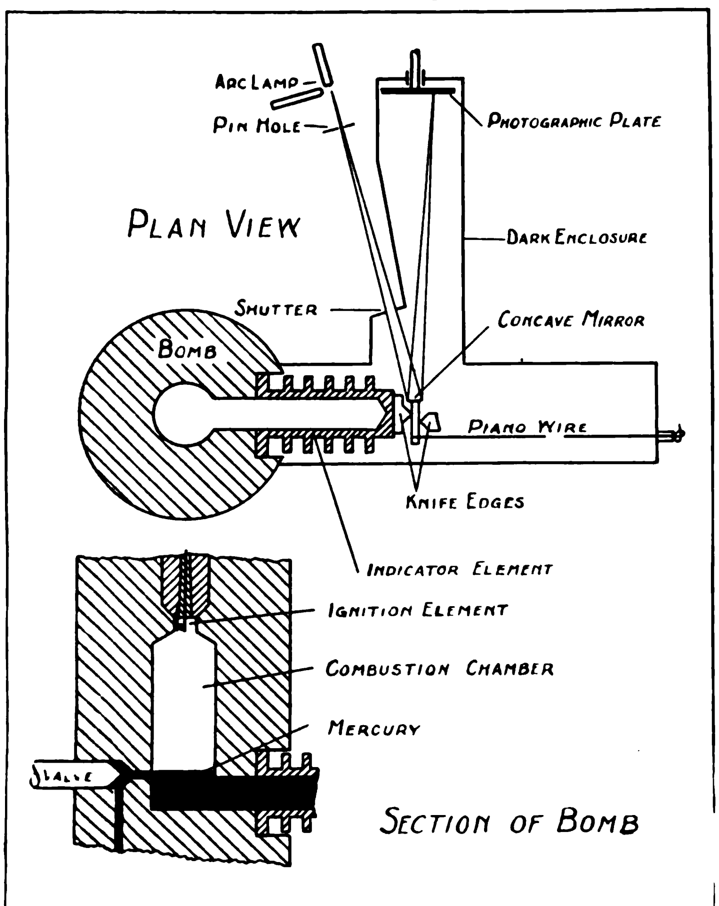


Fig. 1. High Pressure Combustion Apparatus.

In Mason Laboratory for some time past, a series of combustion experiments* have been under way, in which the pressure of combustion runs as high as 8000 lb. per sq. in. To control and obtain records of the process under these very high pressures necessitated the development of special apparatus. The combustion chamber in this apparatus is a small space 1-⅛ in. in diameter and 3-½ in. long formed in the center of a piece of 8-inch steel shaft. Into this chamber over 200 cu. in., at atmospheric pressure, of a combustible mixture of hydrogen and air are compressed, raising the pressure to 1000 lb.

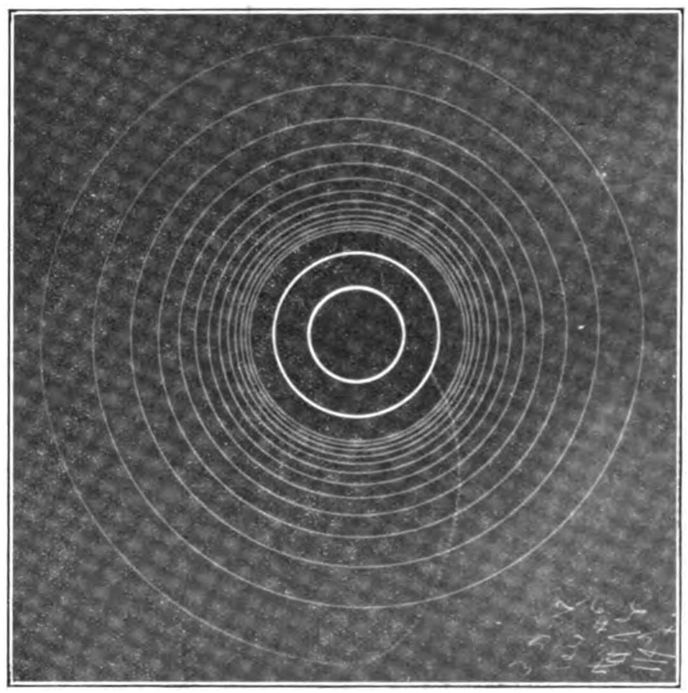


Fig. 2. Typical Air-Hydrogen Combustion Record.

The combustion process is started by a hot wire at the top of the combustion chamber, and although the process is so fast that to the average person it is said to occur without any lapse of time. the flame proceeds from top to bottom in a very appreciable amount of time. The rate of flame travel is made up of two rates; that due to flame propagation from molecule to molecule, and that due to the expansive effect of the burned gases. In the beginning the molecules around the red-hot wire are raised to a temperature at which combustion starts, and the flame spreads to the nearest molecules. As soon as the energy of combustion is liberated the burned molecules raise the pressure at that point and the burned gas expands, pushing the flame front down the combustion chamber and compressing before it the unburned gases. Thus immediately ahead of the flame front, molecules are being driven in a forward direction and immediately back of the flame other molecules are being thrown backward. In considerably less time than 1/100 of a second the flame travels the distance of 3½ inches, the rate being much faster near the end of the process and starting with practically a zero rate at the beginning.

(*Continued on page 46*)

*These experiments were suggested by Prof. W. J. Wohlenburg who co-operated in the running of the first series of experiments.

The Charles Edmund Coxe Memorial Cage

Exceptional Facilities for Indoor Training in Many Sports Offered by What Is Probably Largest Building of Its Type in the World

HAROLD F. WOODCOCK

THE Charles Edmund Coxe Memorial is a field gymnasium of the type commonly called a "Cage" recently erected at Yale Field between Lapham Field House and the Bowl through the generous financial aid of the family of Charles Edmund Coxe, '93S.

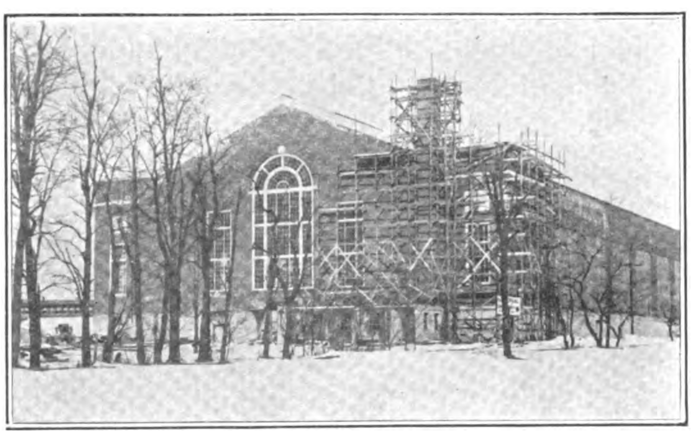
This Memorial building is 330 feet 7 inches long and 159 feet wide and constitutes one huge room. It is accommodating hundreds of undergraduates in athletic exercise, including track events, baseball, lacrosse and football. Soccer and tennis candidates will also have the use of this building later.

The Cage contains a cinder track of eight laps to the mile. It is 10 feet wide excepting the straightaway which is 14 feet wide. The extra width of the straightaway permits hurdlers and sprint men to train at the same time as the distance men who use the entire track oval without interference.

A huge net with side walls of 644 running feet around and 42 feet high encloses the playing space within the track oval. This enables baseball, lacrosse and other squads to practice freely inside the net enclosure without endangering the track men. This net is made of thirty thread cotton twine diagonal mesh and is brown in color. The net is hung to the trusses with steel cables and is suspended from the very ridge of the building 61 feet above the floor level. The playing space inside the net is 255½ feet long and 114 feet wide.

Beyond the end of the track oval an extra bay has allowed the construction of runs and pits for pole vaulting, high jumping, broad jumping and an area for shot putting.

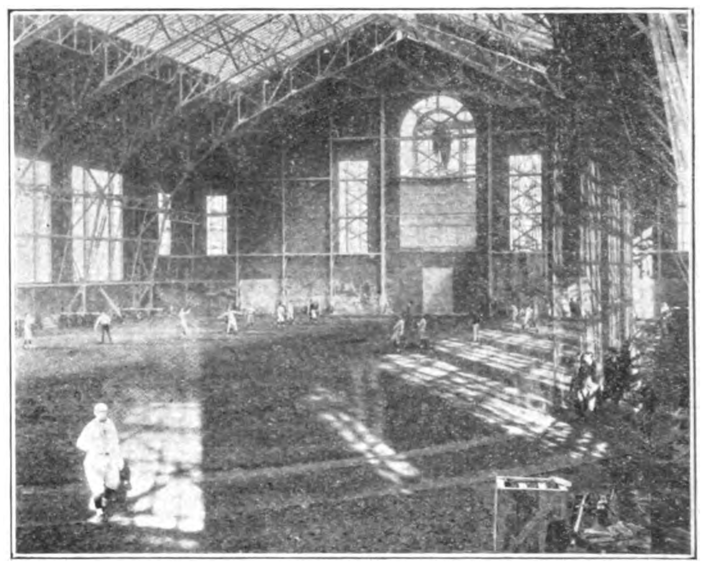
The Coxe Memorial is probably the largest building of its type in the world and it represents a most desirable addition to athletic facilities for the use of the undergraduates at Yale. It not only furnishes a better opportunity for training and practice by the teams that participate in intercollegiate competition but serves as an exercise hall for hundreds of students who engage in athletics on the intramural basis.



The Charles Edmund Coxe Memorial at Yale Field.

The skylight alone, probably the largest single unit skylight in the world, contains 26,000 square feet of glass. The building is electrically lighted by fifty-four 2000 watt lamps with high intensity Holophane reflectors and permits practice in the evening under light conditions which are as satisfactory as daylight. The building is exceptionally well ventilated by small sashes within the large side wall windows and a continuous monitor type ventilator the entire length of the ridge of the roof operated by pulley chains from the floor inside the building.

The building is heated by an oil burner with eight unit heaters, capacity 926,000 B.T.U. at 5 pounds pressure, each heater delivering not less than 10,000 cubic feet per minute. The heating plant is equipped with Bigelow boilers 78 inches in diameter, 18 feet long and 114 3½ inch tubes, 197 horsepower. The building can be regulated to any degree of heat desired but for its purposes the average temperature will be held at about fifty degrees Fahrenheit.



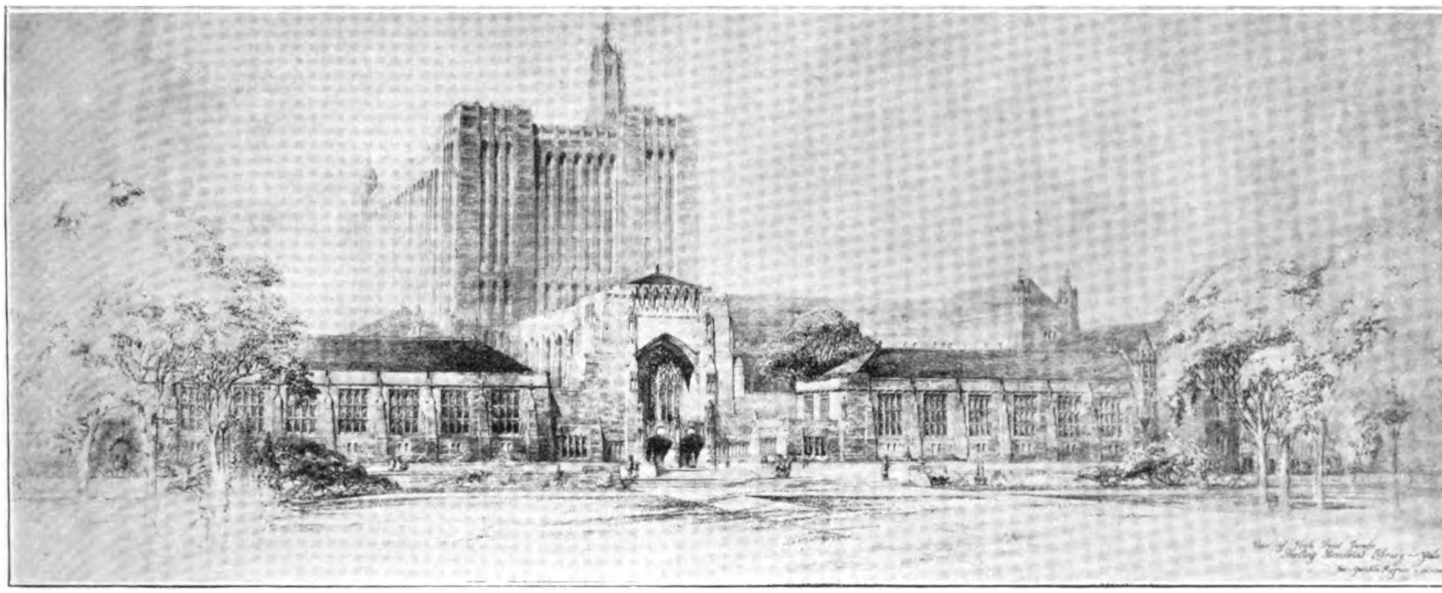
The Base Ball Squad Works Out in the New Cage.

The Charles Edmund Coxe Memorial was designed by Lockwood, Greene and Company, Inc., of Boston, Mass., and built by the National Construction Company of New Haven, Connecticut.

Following are a few interesting figures concerning the building:

Contents	3,611,598 cubic feet
Number of bricks used	746,000
Concrete Stone	1,500 cubic feet
Cement	2,400 barrels
Structural steel	615 tons
Roofing plank	80,000 board feet
Slate	3½ carloads
Copper flashing	6,600 pounds
Windows	6,029 lights of glass

H. F. W.



ABOVE.—*Architectural drawing of the Sterling Memorial Library. This library, which it is hoped will be completed in two years, is being built from the funds of the estate of John W. Sterling, '64. It will cost approximately seven million dollars to construct this building, which will have a capacity of four million volumes. The architect is James Gamble Rogers.*

RIGHT.—*Radio communication on train and between train and signal tower by the General Electric method receives successful test. The test was made on a 100-car freight train running from Selkirk Yards, N. Y., to Utica, N. Y., on the New York Central Lines. Constant communication was maintained between the caboose and the locomotive cab. Both conductor and engineer, though separated by more than a mile of intervening freight cars, were in oral communication at will during the 95-mile trip. Communication was also established between conductor and engineman on the moving train and the signal tower at South Schenectady, when the train was eight miles away. The communication is afforded by small, compact, low-power radio transmitters and receivers operating in the 109-130 meter band. Photo shows an engineman using a microphone in one of the trials.*

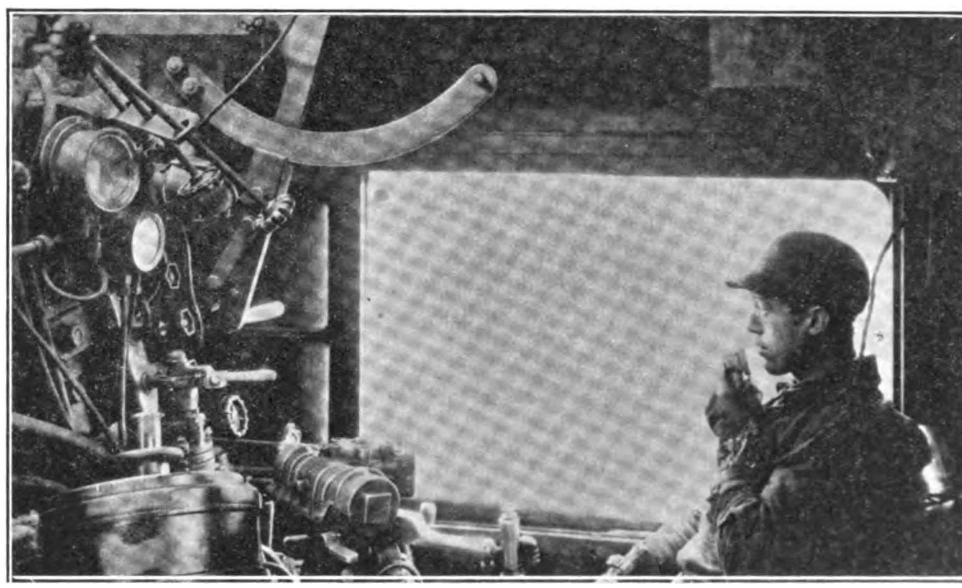
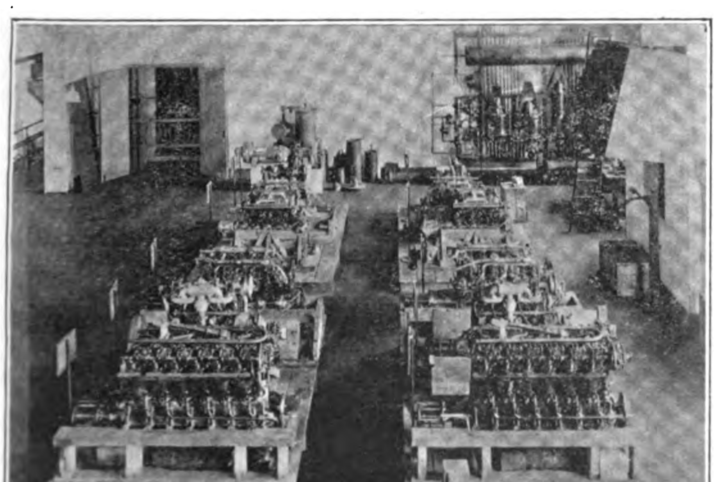
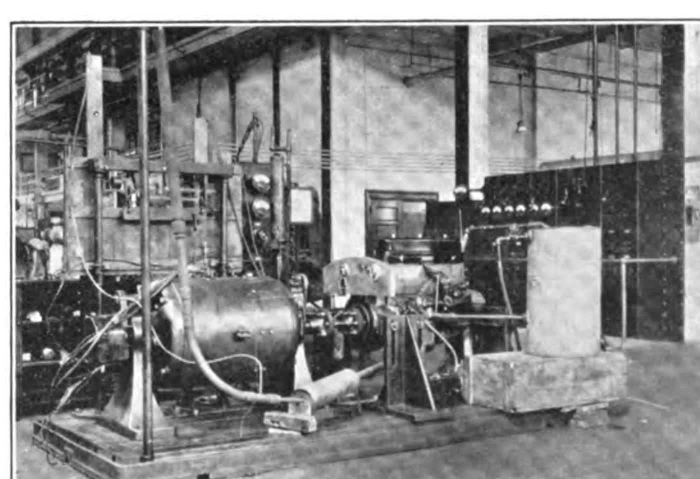


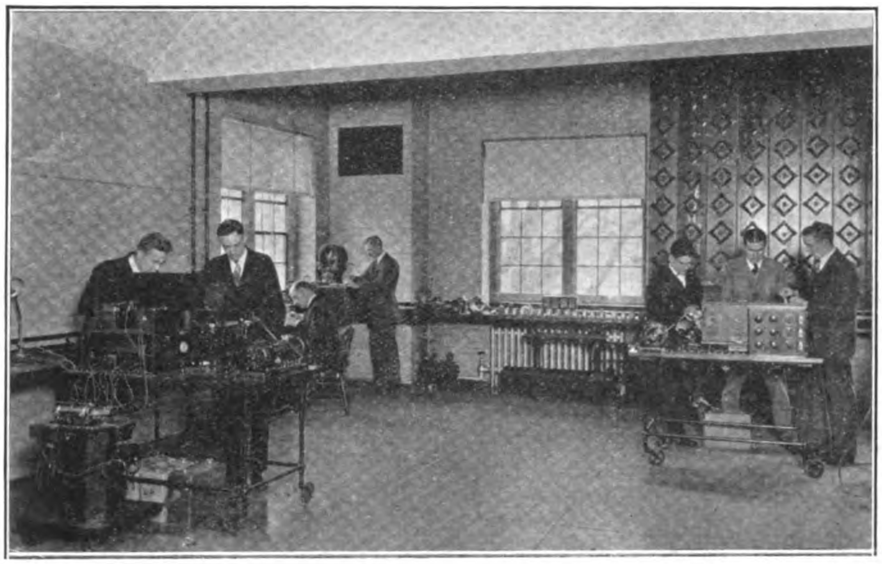
Photo by Underwood



ABOVE.—*An exhibit of twelve airplane engines shown in Mason Mechanical Laboratory.*

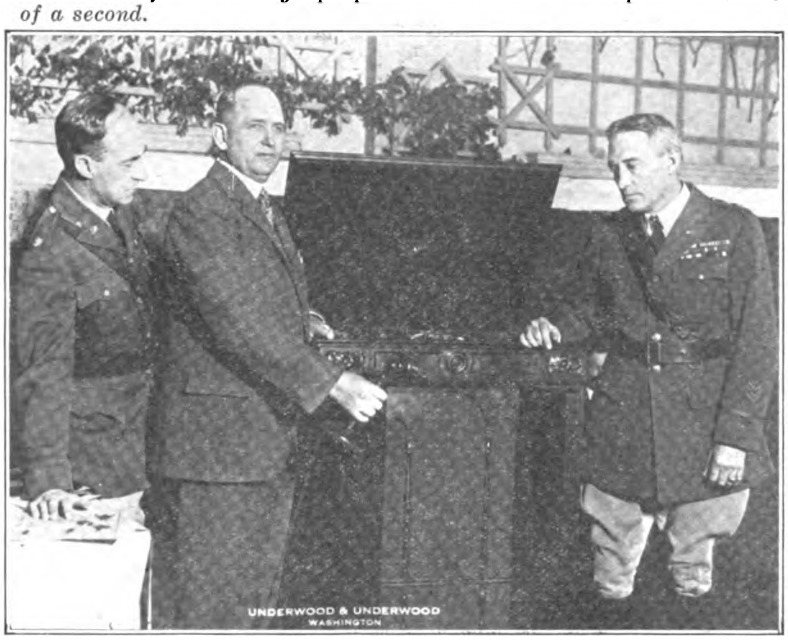


ABOVE.—*A Buick automobile engine is shown on a dynameter test in the Mason Mechanical Laboratory. Students taking Automotive Engineering have been making these tests on various engines during the year.*

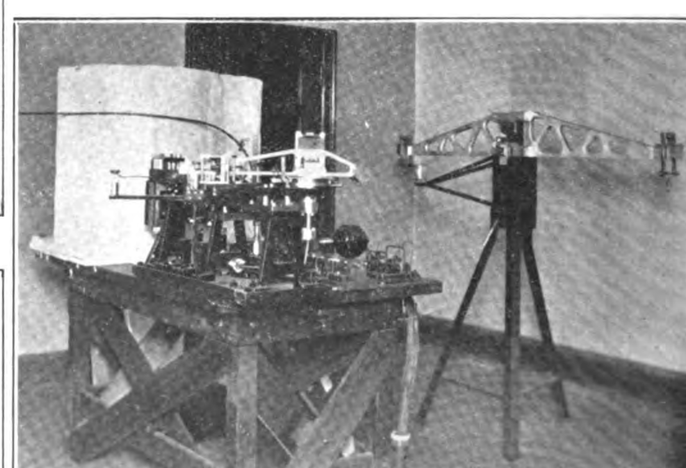


ABOVE.—*Students at work in the Dunham Electrical Laboratory. The group at the left are making an oscillographic study of voice waves and at the right a study is being made of the propagation of waves along a telephone line 800 miles in length. Note the method of mounting the oscillographic equipment. The small piece of equipment at the front end of the table called the Transient Visualizer was developed by Prof. Turner and makes it possible to study on the screen of the oscillograph phenomena which takes place in a thousandth of a second.*

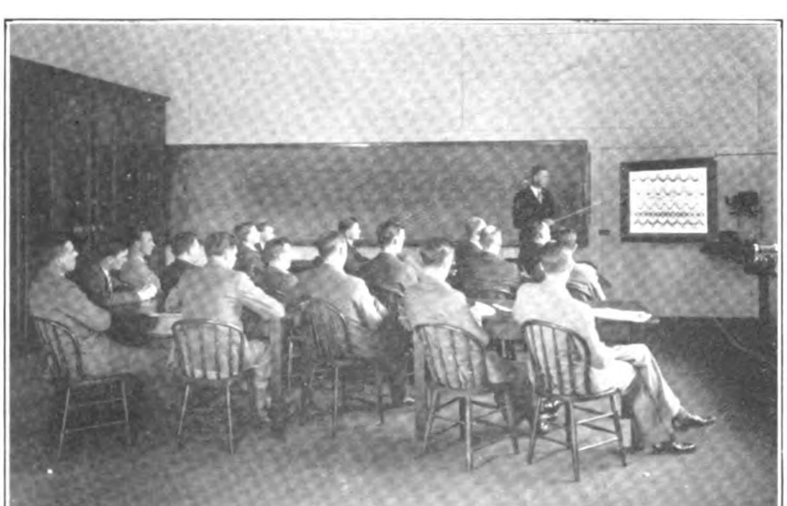
ABOVE.—*Portrait of Professor Treat B. Johnson, recently appointed Sterling Professor of Chemistry. Professor Johnson was graduated in the Class of '98 Sheff. and received his Ph.D. degree in 1901. He has been connected with the Chemistry Department since his graduation and has been a trustee of the Sheffield Scientific School since 1920.*



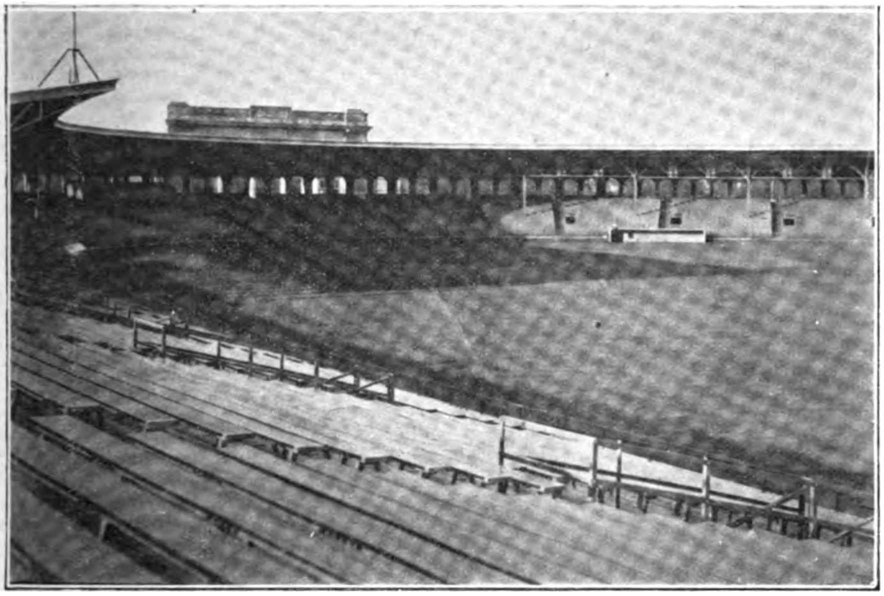
LEFT.—*Before an audience of prominent Washington business men and Government officials, Sergius P. Grace, of The Bell Telephone Laboratories demonstrated the manner in which secrecy in trans-Atlantic telephony is secured. The device consists of a scrambling arrangement or speech inverter, which reverses the high and low voice frequencies, producing an unrecognizable jumble of sounds. Then by another device as is used at the receiving end, he proceeded to unscramble the words. Left to right, Major C. S. Albright of the Army War College, Sergius P. Grace of the Bell Laboratories, and Major General George W. Gibbs, Chief Signal Officer of the Army.*



ABOVE.—*A very delicate apparatus developed by Professor Wohlenberg to determine the properties of sulphur dioxide. It is installed in the Mason Mechanical Laboratory.*



LEFT.—*Prof. Turner of the Electrical Engineering School discussing with the graduate students in communication engineering (Army and Navy officers and civilians) some experimental results obtained by means of the oscillograph in the study of modulation. The two upper curves show the plate current in a push-pull circuit; the third curve shows a voice component, and the fourth curve shows the upper and lower side bands beating. The daylight screen is mounted so it may be folded back against the wall when not in use.*



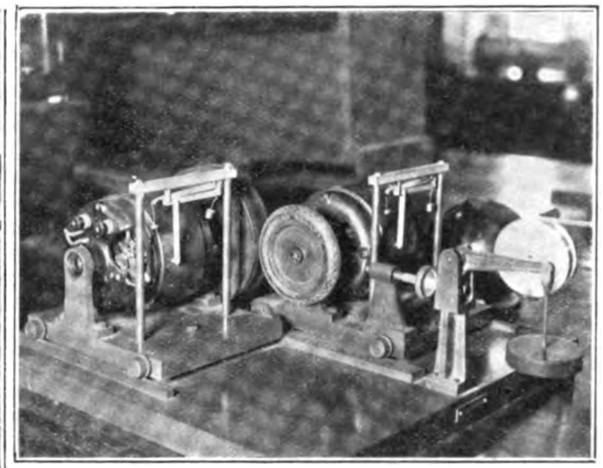


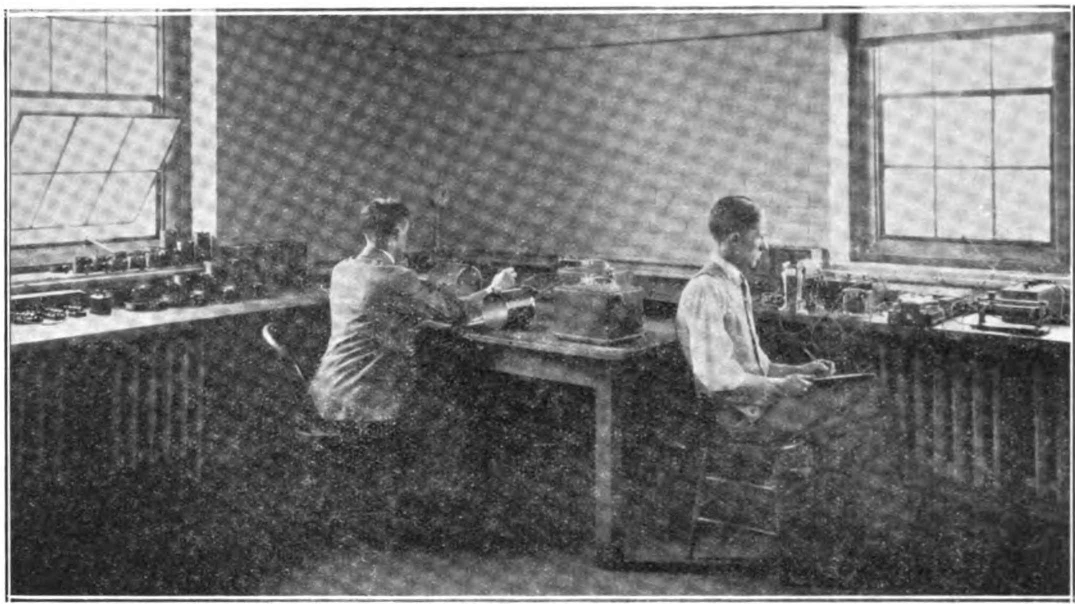
Photo by Underwood

ABOVE.—*Model of auto tire testing machine that demonstrates what tires do on a rough road. This apparatus, with countless other scientific and industrial material, has been acquired for America's great industrial museum which will be constructed in New York City.*

ABOVE.—*The recently completed baseball stadium, which has a seating capacity of 12,000. All the structural portion is steel; the steps and floors cast cement blocks.*

RIGHT.—*At the left of the picture in Dunham Electrical Laboratory a student is seen investigating the variation of the distributed capacity of coils with coil dimensions. At the right of the picture a student is measuring the inductance of audio-frequency transformers by means of Professor Turner's Constant Impedance Method. This method is particularly good for measuring large values of inductance such as are found in choke coils and audio-frequency transformers both with and without direct current superimposed.*

BELOW.—*E. T. Schwartz with a device employing the interferometer to show that a steel rail may be bent one one hundred thousandths of an inch by the pressure of a thumb.*



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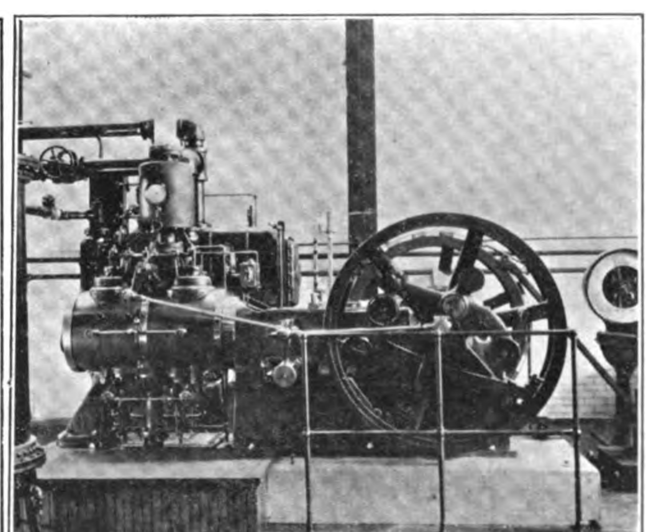
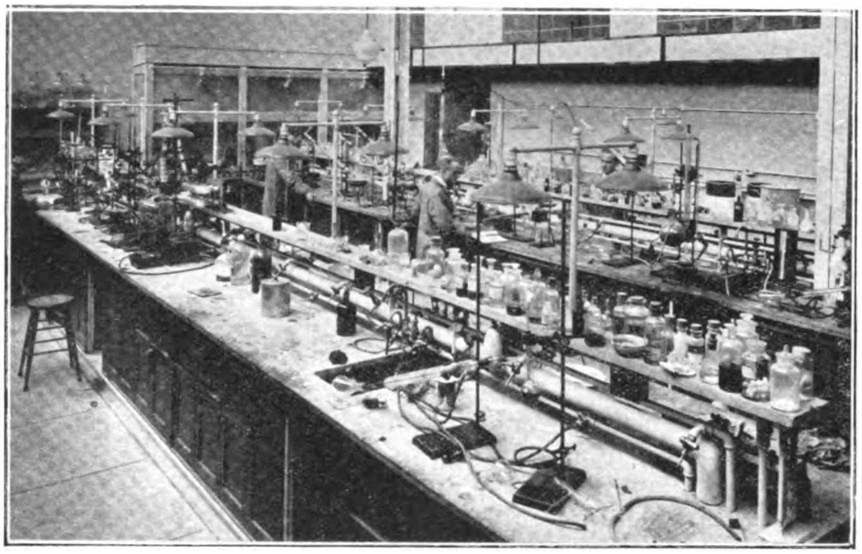
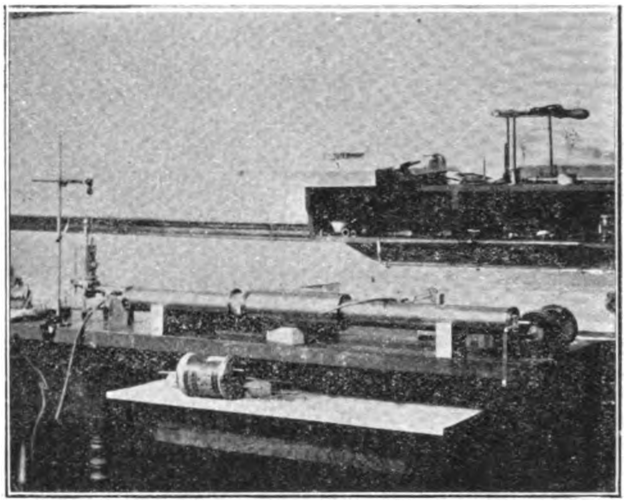


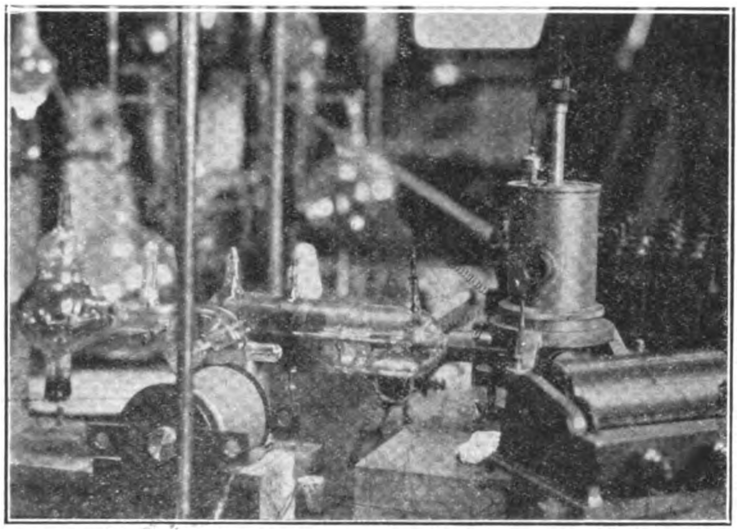
ABOVE.—*A Skinner Una-Flow Steam Engine which has been installed in the Mason Mechanical Laboratory.*



ABOVE.—*One of the general laboratories in the Sterling Chemistry Laboratory, in which students in advanced Organic Chemistry are at work.*



ABOVE.—*Apparatus developed by Professor Zeleny of the Physics Department for the study of the mobility of ions. The ions are liberated at the periphery of the middle section of the tube and are carried by a current of gas passing through the tube.*



ABOVE.—*Mr. J. E. Henderson is determining the critical angles for soft X-rays. Visible light can be reflected, while ordinary X-rays can not, except for very small angles. This apparatus is to determine at what intermediate frequency or frequencies this change takes place.*

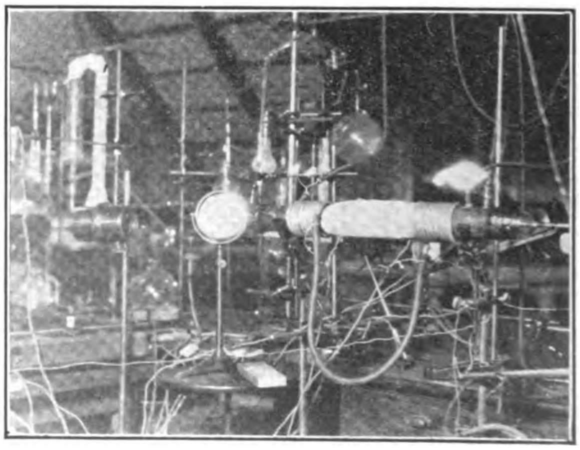
Photo by Underwood

ABOVE.—*Two thousand physicians and surgeons of three continents assembled in Chicago for the sixth annual meeting of the American College of Physical Therapy. Photograph shows Dr. Norman E. Titus, president of American College of Physical Therapy, giving lecture on new X-Ray apparatus. Infra X-Rays or borderline Rays is a newly discovered energy that is deeper in penetration than ultra-violet, and not as deeply destructive as X-Rays. It has great promising value in the treatment of stubborn skin disease and skin cancers. This is a demonstration for treatment of cancer on the lip.*

Photo by Underwood

ABOVE.—*Photograph shows, left to right, Coroner's Chemist William D. McNally and Assistant John D. Endriz, taking serum from a rabbit, to be used in detecting human blood stains. Rabbits are used in the solution of murder mysteries, by the coroner of Cook County, Ill.*

RIGHT.—*Dr. E. L. Kinsey, National Research Fellow in Physics, is carrying on experiments upon the spectrum of the fluorescent light emitted when sodium vapor is illuminated with light of different wave lengths. Recently by stimulating the molecules, the atoms have been caused to respond and emit their characteristic radiation.*



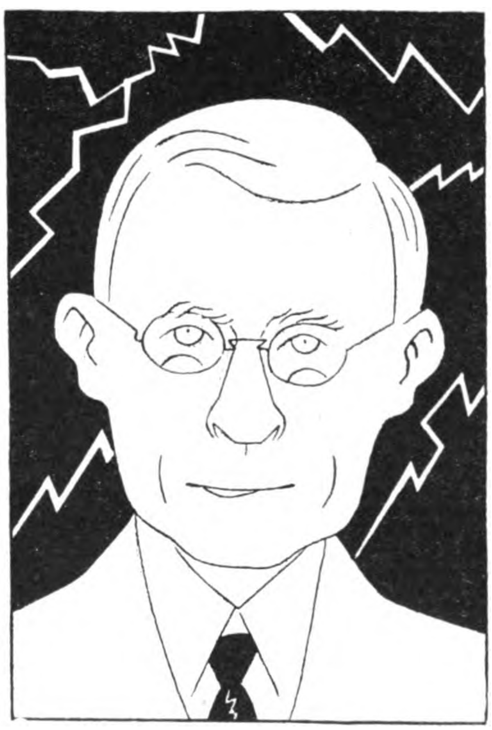
P·E·R·S·O·N·A·L·I·T·I·E·S

No. 4. *CHARLES FELTON SCOTT*

WHEN Charles F. Scott first saw the light at Athens, Ohio, in 1864, it was the light of an oil lamp. There were no electric lights. In 1881 young Charlie, a tall and raw boned freshman, bent his back over a desk at Ohio University. His father who was president of that university shed an intellectual light over the institution but Charlie's desk had only an oil lamp. Sputtering electric arcs flickered around the main corners of only a few cities; the incandescent lamp with a carbon filament had just been invented. At the end of his Sophomore year he went to Ohio State University where his father had been appointed president. Alternating current was a laboratory curiosity but, nevertheless, Charles showed at that time the beginning of that aptitude which was to lead him to the front ranks of those who made alternating current a commercial possibility. He piayed in his father's attic tower room for hours with a Lissajou pendulum and studied the resulting designs and figures traced by the pen. His fundamental knowledge of alternating current had its beginning in the analysis of these figures.

In 1885 he graduated from Ohio State University. Another incident of world wide importance occurred that same year. George Westinghouse purchased the rights for the use of the Gaulard-Gibbs patent. This patent covered the basic idea of the transformer. The transformer has made possible the tremendous power systems that we know today. It has been a great factor in giving America its industrial leadership.

Charlie Scott with a diploma under his arm betook himself to Johns Hopkins for a graduate course. From Hopkins he took that dive into the maelstrom of life where, away from the sheltering influences of college, men swim by their own efforts. The life belt that Charlie took hold of was feeble in those days. He became an electrician's helper. Yet few men have ever risen higher in their profession than has Charles Scott. But the course of that rise was not without its setback; there were slips at times. In the early days he had not learned the principles of thermodynamics as well as he had the principle of electricity. But knowledge came with experience. His first job was engine testing at the Westinghouse Company. There he learned by experience that when oil runs out of a bearing friction is increased and as friction is increased so is heat production. Incidentally that engine burnt out a bearing. The circumstance was not appreciated by those for whom he worked—they did not need the experience. Later Charles Scott became the chief electrical engineer of the Westinghouse Company. In 1911 he left that company to assume his present teaching position at Yale.



There is scarcely any field which forms a part of the general science or profession of electrical engineering in which Professor Scott has not made some worth-while contributions. Electrical engineering has been his vocation and the development of his vocation has been his avocation. It would be hard to pick his most important contribution. From an engineering standpoint his work in inductive coordination, that is, the interference between communication and power circuits, was invaluable. His accomplishments in this field brought him an international reputation. When inductive coordination became a serious problem existing in Italy Professor Scott was chosen by the Italian Government to suggest means of overcoming the difficulty between railway power circuits and the communication circuits.

Early in his career he assisted Nikola Tesla in the development of the alternating current motor, patents for which were purchased by the Westinghouse Company. He was of valuable assistance to Tesla, their work is said to be the greatest advance ever made in the industrial application of electricity.

The name of Scott has became a part of the nomenclature of the science. There is perhaps no better index of a man's contribution to his profession than to have his name become a part of its language. His invention of the two-phase three-phase method of power conversion bears his name, the "Scott-connection". In 1895 the three-phase method of power generation and distribution was developed by the General Electric Company. This system was economically superior to the two-phase system then in use. The Westinghouse Company was in no position to change immediately to the new system because their machines were of the two-phase type. They were on the verge of losing several of their large contracts to their competitor. Scott at once suggested a soluton for the difficulty. He invented the method for converting power from two-phase to three-phase. The older engineers laughed at him when he told them of his idea. His ingenious method was sent to the laboratory for a test. Those who tried it reported that it would not work. With implicit faith in his method he went to the laboratory to find the error in their experiment. The men who tried it first had violated a fundamental principle of his connection. Needless to say the Westinghouse Company did not lose its contracts.

Scott was one of a group of Westinghouse engineers who under the leadership of George Westinghouse, began the exploitation of the alternating current system. Their activities met with opposition. This opposition came from men of great repute. It is

(Continued on page 42)

Astronomy

The Yale telescope in Johannesburg, South Africa has been in operation for about thirty months. Its principal work is the determination of distances of stars, and for this it is necessary to secure plates of each star over a period of at least two years. Accordingly, complete material is now at hand for some of the stars, and these plates are being measured as rapidly as possible. The results are satisfactory; they show that the telescope is equal in accuracy to any other with which stellar distances can be determined.

More than four thousand photographs are obtained each year with this telescope. This is about equal to the total number of photographs that are being secured by the northern observatories that are engaged in the same work. It therefore appears that within ten years our knowledge of the distances of southern stars will be nearly abreast of our knowledge of the northern.

Civil Engineering

Some rather radical readjustment is planned for next year in the senior civil engineering curriculum. As a means of gathering together and applying the principles and methods taught up to this point in the several branches of instruction, there has been introduced a full year's course called "Projects in Civil Engineering." In this course the student will take up, in succession, several assumed pieces of construction, approaching each with as nearly as possible the attitude of a professional engineer. That is, beginning with a preliminary analysis of given conditions and requirements, he will carry along, step by step from week to week, a comprehensive study of the various phases of his problem, culminating in a complete design, plans and specifications, estimate and report. Since each project will be more or less composite in its nature, involving, perhaps, steel and concrete construction, the building of roads and the use of water for some purpose, the several members of the staff, each expert in his own field, will all share in the teaching. The student will thus be brought to see that his various subjects supplement each other and form parts of a coordinated educational plan. A number of minor curtailments will be made in the advanced portions of other senior subjects to make room for the "projects course."

Mr. W. Joshua Barney, President of the Barney-Ahlers Construction Corporation of New York City and chairman of the Structural Division of the American Society of Civil Engineers, spoke recently before the Student Branch, American Society of Civil Engineers on *"The Relation of the General Contractor to His Banker."*

(Continued on page 36)

Chemistry

Professor Saxton and Mr. Sperlin are working on the measurement of the area of the naptheline ring by means of the use of surface films on water.

Professor B. F. Dodge is working on catalytic gas reactions under high pressures, for the purpose of obtaining organic compounds of commercial importance from carbon monoxide and hydrogen. More than a year has been spent in setting up special equipment for studying these reactions on a small scale. Mr. Geoffrey Robbins, 1927S, is working with Professor Dodge in this field, on a fellowship from the Mellon Institute of Industrial Research. Messrs. J. A. Huffman and M. C. Molstad are also engaged in this work.

The Seniors in Chemical Engineering are working under Professors Curtis and Dodge on a number of small research projects such as the study of a rectifying column, problems related to the low temperature carbonization of coal, heat transfer to oils flowing in standard pipe, and certain ammonia absorbents that might have an application to refrigeration .

Physics

Mr. Donald Cooksey has installed a hydrogen molybdenum furnace made by the General Electric Co.

Prof. L. W. McKeehan gave a lecture on Feb. 23 before the Chemical Club at Princeton on "Metal Crystals."

Dr. E. O. Lawrence has received a call to an Assistant Professorship of Physics from the University of California.

A part of the storage battery plant which has been out of service for some time is being replaced by new cells.

The new air liquifier which is being constructed in the shop and which includes an improvement resulting from an investigation made in the laboratory is nearing completion.

Biology

Professor Coe is working on the regeneration of worms and endeavoring to determine the smallest fragment that is capable of reproducing the entire animal. He has found that tiny pieces 1/20,000 the size of the original animal is capable of reproducing a miniature of the whole. This is comparable to the size of the end joint of the little finger, as compared with the body of a human being.

Professor G. A. Baitsell, a member of the national executive committee of Sigma Xi, is being sent out by that organization to install two new chapters. He will give lectures in addition to the installations. He is also making a survey of the chief vivaria of America.

Miss Catherine Lucas of London is spending the year at the Osborn Laboratory as a Sterling Research Fellow working on certain problems in Protozoology under Professor Woodruff's direction.

Geology

Emeritus Professor Charles Scheuchert has returned to Peabody Museum from the southwest where he has been studying Stratigraphic Geology.

Mr. H. W. Rose is leaving the department for this term to go to Portuguese West Africa to conduct a geophysical survey in connection with a study of the petroleum possibilities of that region. This will be done by means of a gravity torsion balance of the Budapest type.

Messrs. D. H. Selchow and H. H. Hess, who have been graduate students in Geology for this year, are leaving in May for Northern Rhodesia, Africa, to carry on geological investigations for the Anglo-American Concessions Company.

Peabody Museum.

The exhibit showing the evolution of fossil horses has just been revised and renewed by Professor R. S. Lull and Dr. Malcolm Thorbe.

The Geological Department of Peabody Museum has recently secured a large fulgorite or lightning tube. Such a tube is formed where lightning has struck a bed of sand and fused the sand as it descended forming a hollow glassy tube. The specimen was found on the shore of Lake Congomond, which is near the edge of the northern boundary of Connecticut, and was dug up by Professor C. O. Dunbar. Plans are being made to display it in the Hall of Minerology.

Mechanical Engineering

The 44th annual meeting of the Connecticut Society of Civil Engineers was held in the Mason Laboratory, on February 21 and 22, 1928. The two-day conference was very well attended, the lecture room being crowded at times until standing room was no longer available.

A one-day conference on Industrial Gas and Coke Heat was held in New Haven on Wednesday, March 21, under the direction of the Mechanical Engineering Department in cooperation with the Manufacturers' Association of Connecticut. At the morning session in the Mason Laboratory lecture room Professor H. A. Curtis commented on "Fundamental Facts in the Coke Forming Process," and L. E. Seeley on "Combustion Characteristics of Coke." There were papers and general discussion on the construction, operation and application of industrial furnaces and control equipment by representatives of manufacturers, research organizations and industrial users of gas and coke. Professor S. W. Dudley presided at the morning session in the lecture room of the Mason Laboratory; Professor Seward at the afternoon session, and Mr. H. A. d'Arcambal of the Pratt & Whitney Company, Hartford, Conn., at the evening session, the latter two sessions being held in Lampson Lyceum. A few typical furnaces, control devices and indicating and recording instruments were on exhibition at the Mason Laboratory during the conference.

Professor W. J. Wohlenberg recently attended a meeting of the Committee on Research of the American Society of Mechanical Engineers in New York for the discussion of possible plans for fundamental research on certain problems of radiant heat utilization in power boiler furnaces.

Mr. L. E. Seeley attended the annual meeting of the American Society of Heating and Ventilating Engineers in New York, January 23–27.

(Continued on page 36)

Electrical Engineering

A. I. E. E. Convention.

The annual Convention of the Northeastern District of the American Institute of Electrical Engineers will be held in New Haven May 9th to 12th. There will be technical sessions covering numerous branches of electrical work, including papers relating to some of the notable electrical features in Connecticut at the present time, such as the Mercury arc rectifiers which are supplying the street railways of Bridgeport, the frequency changing apparatus by which the Devon power plant will supply power to the New Haven Railroad, the Mercury turbine of the Hartford Electric Light Company and the Rocky River hydroelectric development near New Milford.

Excursions will be arranged to these and other points.

(Continued on page 36)

Medicine

Appointments in School of Medicine.

Dr. Ernest Van Campenhout has been appointed Instructor in Anatomy for the coming year.

Dr. Herman Schlionsky has been appointed Assistant in Anatomy for next year.

Mathematics

Associate Professor J. K. Whittemore is on leave of absence for this term and is taking courses at Princeton University.

Professor Eisenhart and others are taking courses in Riemannian Geometry.

At the February meeting of the American Mathematics Society at Columbia University papers were read by Professor W. A. Wilson, Associate Professor J. I. Tracey, Dr. L. T. Moore, and Dr. T. H. Rawles.

Mining and Metallurgy

Professor C. H. Mathewson delivered the annual Institute of Metals Lecture before the American Institute of Mining and Metallurgical Engineers on February 22d. His subject was "Twinning in Metals."

The New Haven Section of the American Society for Steel Treating held a meeting in the Hammond Metallurgical Laboratories on March 8th. The main address of the evening was given by Mr. E. E. MacQuigg of the Union Carbide Company, whose subject was "Manufacture, Use, and Heat Treatment of Stainless Steel."

A new Bausch and Lomb metallurgical microscope has been added to the equipment of the Metallurgical Department.

Mr. J. A. Savage, '04S., a prominent Mining Engineer and Operator of Duluth, Minnesota, inspected the Hammond Metallurgical Laboratory March 8th. Mr. Savage on that day addressed the Freshman class of Yale.

Forestry

Dean Graves addressed the Washington section of the Society of American Foresters on February 27, on the subject *Education in Forestry.*

Professor Record gave a talk before the members of the Wood Industries Division of the American Society of Mechanical Engineers in New York on February 24, on *Our Need for Knowledge of Tropical Timbers.* Mr. Record is giving a series of talks in New York before The Nylta Club, a junior organization of The New York Lumber Trade Association, on the general subject of *The Forest Regions of the United States.*

Mr. Llewelyn Williams, of the botanical department of the Field Museum of Natural History, was at the School during February and March in furtherance of the plans for cooperation between that institution and the tropical department at Yale.

Professor Toumey had an interesting discussion of taxes and their relation to forest production in New England in the Boston Sunday Globe of Feb. 5, 1928.

Professor Garratt is the author of an article on "Another Way of Lessening Your Fire Risk," which appeared in the March, 1928, issue of *Garden and Home Builder.* During the past winter he gave talks on *The Paintability of Wood,* and *Veneers and Plywood* before the Nylta Club in New York.

Spring Field Work.

The Spring field work will begin on Monday, March 19, with twenty-four Seniors in attendance. As usual, headquarters will be in the Elk Pasture near Urania, Louisiana. Professor Chapman will have as an assistant, L. W. Rathbun, '27, Field Assistant at the Forestry School.

The Yale Forest Club.

A number of very interesting speakers appeared before the Forest Club during

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Physiology

Professor Henderson has published in the Journal of the American Medical Association a paper entitled "Prevention of Asphyxia in the Newborn." It deals with methods for avoiding the death of infants at birth by the use of the inhalational treatment developed in the Laboratory of Applied Physiology.

Professor Haggard is engaged in collecting material for a book dealing with medicine in its relations to civilization.

WHY WAIT

IT has been recognized for some time that the most pressing problem before the University authorities at the present time is the proper housing of the Freshman class. President Angell expressed a similar opinion to the graduates on Alumni Day. But when we remember that the Endowment drive is just finished and that Yale's benefactors have already given until it hurts, and that "not one cent" is available for buildings, some of us wonder how long this need is going unsatisfied. It is true, as President Angell so well remarked on Alumni Day, there never was a time when there were not pressing problems facing Yale, but was there ever so urgent a need which could be satisfied so easily?

Let us take a look at the figures. We are told by responsible builders that a comfortable dormitory, not a Harkness, but one that would fit in well with Yale's campus development, can be built to accommodate 100 men for about $4,000 a man. We are also told that Yale's dormitories have been yielding the University, after all charges and expenses, about 2% on the investment. Why then couldn't Yale go out and borrow the $400,000 necessary to build the unit? What financial institution would be unwilling to lend Yale the money at a low rate, possibly 4½% or 5%? The net annual cost to the University would be only 3% on $400,000 per year, or $12,000.

There are many who immediately will say that a University should not spend more than it had, that this would be an undesirable precedent. However in view of the present emergency where half our freshman class is living in converted houses strung around the outskirts of the campus, isn't it worth chucking a little precedent aside and spending $12,000 a year until someone helps the University buy the property in its own name? And why shouldn't a University prosper on borrowed money? Practically every business enterprise in this country has done so.

* * *

COMMITTEES REPORT ON UNIVERSITY AFFAIRS

University Authorities Cooperate in Studying Conditions Affecting The Sheffield Scientific School: Progress Has Been Slow but Definite

MR. O. S. LYFORD, Chairman of the Association's Committee on University Affairs, recently completed a report of the activities of the Committee during the past year. The Association has studied the conditions affecting the Sheffield Scientific School through this committee for about two years and has made a number of recommendations.

Mr. Lyford's report summarizes what has been done up to this time and brings to our attention the cooperation the Committee has been receiving from the University authorities. The report in part:

Recommendations of Y. E. A. Committee.

1. More dormitories available for Sheff men.
2. New building at the head of College Street.
3. Handbook for guidance of students and their advisors.
4. Appointment of Directors of Student Guidance.
5. A campaign of enlightenment.
6. Continual readjustment of methods of selecting students.
7. Candidates for admission required to state preference of occupations and courses of study.
8. Elimination of snap courses from both undergraduate schools.
9. Informational courses in Freshman year.

Recommendations of the Yale Advisory Board's Committee.

A. Freshmen enrollment to be in two quotas, one for each upper school.

B. Each candidate required to state preference as between College and Sheff.

C. Transfers from course originally indicated only with the approval of University Authorities.

D. University to provide for an orientation week each fall before the University opens, with an ample number of advisors.

E. Continual readjustment of Freshmen courses to the end that they shall be more closely adjusted to the courses in the upper schools.

The reports of these committees have received a great deal of attention by the University authorities during the last two years and we are pleased to report that although the progress has been slow, it has been definite and although our recommendations regarding throwing open the existing dormitories to Sheff men and regarding the enrollment in quotas have not been approved, the reasons have been material.

The dormitory situation can be solved only by more dormitories for the Freshmen and for Sheff upper classmen. These are obtainable only with large gifts to the University. Our special committee on dormitories is working on the subject continually and reports progress.

Very definite progress has been made on plans for a new South Sheff. The Architectural Committee of the University has voted to prepare plans and Dean Warren has submitted to them definite recommendations as to the facilities to be provided in this new building. There are already possibilities of securing at least a part of the necessary money. Subsequent to the meeting, Mr. Zantzinger, 1892 Sheff, was appointed to prepare preliminary plans and he is now at work upon them.

Dean Warren and members of the Sheff faculty have been working on the handbook, and we hope that such a book, covering Sheff courses at least, will be issued during this college year.

The recommendations regarding administrative procedure, with the exception of the quota recommendation, are being acted upon favorably and we feel sure of wise procedure along the general lines suggested.

This leaves two very important recommendations regarding one of which we desire to report in detail at this time.

Directors of Student Guidance

This recommendation, which was in furtherance of views previously expressed by President Angell, has been put into effect in

a very gratifying way by the establishment of a new department known as the Department of Personnel Study, constituted as follows:

Director, Albert B. Crawford, 1913, who has been at the head of the Bureau of Appointments for some years.

Assistant, John C. Diller, 1924, who will direct the work of the Placement Bureau.

Assistant, Edward S. Noyes, 1913, Assistant Professor of English and last year's Chairman of Freshman Councillor Committee.

Administrative Council, consisting of the Provost, the Deans of the three undergraduate schools, the Chairman of the Board of Admissions, the Director and representatives of the Student Councils.

Mr. Crawford is eminently qualified for the study of these student problems and his experience in the Bureau of Appointments has given him exceptional preparation for the larger responsibilities. He and his assistants are much interested in Sheff and as most of the calls that come from employers to the Bureau of Appointments are for men for occupations in industry and commerce, they naturally feel the importance of the Sheff courses for men who have the mental qualifications and the desire for careers in engineering and administrative lines.

These men, with the administrative council behind them, will not merely study the students and their problems, as the name of the department indicates, they will counsel with the students and with others to whom the students go for advice. They, therefore, are the Directors of Student Guidance for whom we have struggled.

As the Administrative Council of this new department and the Board of Admissions are made up of many of the same men, the two functions of student selection and student guidance are closely allied, as they should be, and the University is therefore effectively launched on the program in whch we are so much interested.

To insure close cooperation of our Engineering Association with the work of these bureaus, their members were invited to meet a sub-committee of the Engineering Association at lunch on October 23, at the Graduates' Club in New Haven. There were present:

For the University—
Secretary Lohmann.

For the Board of Admissions—
Chairman Corwin.
Dean Warren and Prof. Lafayette Mendell, representing Sheff.
Dean Mendell and Prof. Luquiens, representing the College.
Dean Waldron and Prof. Longley, representing the Freshman Faculty.

For the Department of Personnel Study—
Mr. Crawford and Mr. Noyes.

For the Yale Engineering Association—
Messrs. Ferguson, Ryder, Brewer, Alling, Cheney, Blakeslee and Lyford.

The discussion was highly instructive and the men of our Committee were much impressed with the information given us as indicative of the earnest and intelligent work which has been and will be accomplished. This information may be briefly summarized as follows:

Limitation of numbers has made admission to college a selective process at Yale as well as at most good colleges in the East. However, this process as at present in operation at Yale, has not turned away any considerable number of students whose records indicated that they were in every way adequately prepared to succeed in a college course.

The Board of Admissions.

About 22,000 candidates take the preliminary and final college board examinations each year. Of this total in 1926, 3,097 wished to enter Yale, 2,154 Princeton, and 2,021 Harvard. There were 1,760 final applicants for admission to Yale in 1927. Yale admitted to the Freshman class 887, of whom 26 were admitted by transfer from other colleges or universities, and 41 were readmitted to the Freshman Class from earlier classes.

This new Freshman Class came from 43 states, the District of Columbia, Hawaii and Canada. 669 came from the New England States, New York, New Jersey and Pennsylvania.

(This distribution clearly demonstrates that Yale is a national University, but suggests that to properly fulfill its destiny as such, there should be a larger proportion from outside the Northeastern States. In this connection attention is called to the fact that the growth of great state universities amply provided as they are with almost unlimited funds, has made it unnecessary for the great body of students throughout the country to seek admission to an eastern university. The facilities of such a university should be utilized by the few who are best able to profit by national contacts.)

The distribution according to preparatory schools has not been published, but from a partial list of 180 of the present Sophomore Class in the Scientific School, which presumably includes the most promising men of the class, we find the following:

18 Preparatory Schools sent	92
28 other Preparatory Schools sent ...	28
37 High Schools sent	60
83	180

These figures show that we have a widely distributed clientele and through these schools as well as through our alumni, we can carry on an effective campaign of enlightenment when properly prepared to do so.

Referring to the basis of test for admission, Prof. Corwin reported as follows:

The college board examinations are prepared by a committee of which one-half are college professors and the other half teachers of secondary schools. The examiners are also divided equally between the colleges and the secondary schools.

The College Entrance Examination Board holds sessions at some two hundred cities, schools and other centers and thus brings the examinations pretty nearly to the door of every aspirant for admission to Yale.

Yale some years ago, set up the so-called Plan B or comprehensive examination as an alternative to the regular college board examinations. This has since been adopted by many institutions. Under this plan the student is asked to report through his school principal the complete record of his four-year preparatory course. If this is satisfactory, that is, if in the eyes of his teachers, he is adequately prepared for college work, Yale contents itself with examining him, as far as the question papers permit, on the work of his senior year only. The examination in English, is, however, comprehensive in type and covers the whole preparatory course.

Courses of study differ materially in the secondary schools of the country. The courses in the eastern preparatory schools are prepared with special reference to the program of the college board examinations, whereas the courses of many of the western high schools are planned quite differently. As a consequence, the candidates for admission from the eastern secondary schools have had an easier time under the college board examination than have

the students of the western schools. This has discouraged many of the latter or led them to conclude that to secure admission to Yale, they must spend at least one year in an eastern school. Furthermore, a student who decided late in his high school course to go to college, was distinctly handicapped. Under Plan B, these handicaps are removed and a good student who has followed any well planned course in the secondary school can have equal chances for admission to Yale. As stated before this, Plan B was originated at Yale.

The second important innovation initiated at Yale, is the selection of the entering class after the June examinations. With a limited enrollment, this is much fairer to the students, as those who are not selected have ample time to decide on other colleges, furthermore, intensive cramming between June and September is not of much educational value. This plan was first put into effect in 1927 and all agree that it was highly successful.

The college board examinations, either Plan A (extensive tests) or Plan B (comprehensive tests) are only one factor in arriving at the weighted average which determine the candidates standing. Men are admitted to Yale on the basis of four tests:

a. College Board Examinations—Plan A or B.

b. School record for four last years.

c. Scholastic aptitude test.

d. Confidential report of head master regarding intellectual promise, stability and other qualities which make for success.

The greatest weight is given to the record of the last four years, in other words, the Board asks the student primarily, "What have you done?"

This answers the criticism that Yale is measuring everybody with one yard stick. Even the college board examination cannot be characterized as a yard stick as used at Yale. The subjects required of candidates for the degree of Bachelor of Science or Bachelor of Philosophy are only those on which any man capable of an education should be well enough prepared to pass the minimum mark, and if a student is good in science and mathematics, for instance, and poor in history and languages, the high score in the subjects that show him a good candidate for Sheff may bring the low score in the other subjects up to the required average.

Students are no longer admitted with conditions such as used to be a heavy drag on them in the first years of college.

The scholastic aptitude test is a psychological test which was adopted by the College Entrance Board in 1925 and first used in 1926. Its value is uncertain but one of the large foundations has appropriated the sum of $25,000 a year for five years to study the subject and determine what the results mean and how accurately it measures intellectual qualities. At present it is used at Yale mostly as a check on the other tests used. For instance, if a candidate shows up poorly on the college board examination but has had a good score in the secondary school and does well on the scholastic aptitude test, there is reason to believe that the low score in the examination was due to nervousness or some other cause which should not count against him.

Dean Warren reported that in his judgment the class of 1931 is the best Freshman Class ever admitted and that he got all the good men whose weighted average was sufficient for entrance and who signified a preference for a Sheff course.

There was no attempt made to size up the scientific abilities of those who signified a preference for the college or had no preference.

Dean Mendell reported that less than 5% of all the students in the College are taking enough science to approach the 60% limit

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COMMITTEES REPORT ON UNIVERSITY AFFAIRS

(*Continued from page 32*)

and that there are only four students in the college who are actually majoring in science.

A Campaign of Enlightenment.

The other important recommendation which should now have our consideration is the "Campaign of Enlightenment".

A boy coming to Sheff under the present dormitory and social conditions must have definite purpose and strength of character to steer a steady course, but this is the only kind of boys we want. With these assets, he can get unexcelled preparation in science, industry or commerce for life.

We should inaugurate without further delay the campaign of enlightenment for which the committees have seen the necessity from the beginning.

This campaign, as recommended in the report of this Committee in January, 1926, should be one carried out by the faculty and the alumni, to acquaint the prospective students, their parents and friends and preparatory school masters with the conditions to be considered before a boy makes his choice of college courses. The handbook now in preparation will form the text for such advice. There should be committees in every important center, prepared to cooperate with the faculty in this effort.

Respectfully submitted,

O. S. LYFORD, *Chairman.*

BETTER UTILIZATION OF COAL

(*Continued from page 20*)

fine grinding the coke the cell structure is destroyed. We now have a powdered fuel, the specific gravity of the individual grains being 1.5. This is next briquetted with a suitable binder, say coal tar pitch. We now have a lump fuel again, considerably denser than the original coke, but not smokeless. The briquet is then carbonized a second time, carrying the temperature in this case to, say, 900° C., instead of 600° C., as in the first carbonization. The pitch binder is carbonized at once, furnishing a cementing residue between some of the particles of ground coke. But the second carbonization does more than this. The changes in physical character and in chemical reactivity of the coke, interrupted in the first carbonization, are now resumed. The particles increase in specific gravity; they cohere and partially coalesce at their points of contact, drawing closer to each other and giving strength to the briquet as well as increased specific gravity. The final result, assuming that the raw coal was suitable and the process skilfully carried out, is a hard, sound, briquet of specific gravity, say, 1.3, i. e., intermediate between bituminous coal and anthracite. It is, of course, smokeless, and the initial reactivity of the coke has been brought down by the second carbonization. This is not quite anthracite, but a fairly close approximation. The process which we have described seems a round-about way of reaching the goal and so it is. The cost of carrying it through is evidently high, for the company owning the process has not yet succeeded in building a commercially profitable plant although they arrived at this product several years ago.

There are a few other methods of converting bituminous coal into an anthracite-like fuel, but none has attained commercial success. It is something, however, to know that such a conversion can be made, and knowledge of fundamentals will surely prove useful here as in many of the other problems concerning fuels.

CIVIL ENGINEERING

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Mr. Edward W. Bush, engineer of the Fidelity and Surety Department of the Aetna Casualty and Surety Company of Hartford, spoke on March 5th before the Student Branch, American Society of Civil Engineers on "*Contract Bonds*."

Professor Tracy spoke on February 13 to the students of New Haven College on "*Self Education*."

Professor R. H. Suttie has just been appointed a member of a special committee formed by the Boston Society of Civil Engineers to compile and analyze data on the recent New England Flood. Professor Suttie's experience, both as teacher in the field of water supply and as assistant engineer in the Water Resources Branch of the Geological Survey, New England District, qualify him particularly well for usefulness on this committee.

Professor Theodore Crane read a paper before the Construction Division of the American Society of Civil Engineers at their January meeting in New York on "*Engineering Education and the Building Industry*." He gave a short talk on "*Building Construction at Yale*," before the New Haven Architect's Club last October.

Professor Crane lectured, February 15, before the Connecticut Chapter of the American Institute of Architects on "*The Proper Use of Concrete in Building Construction*." He attended the annual convention of the American Concrete Institute at Philadelphia recently.

A group of fourteen water color sketches by Mr. George S. Gleason, Instructor in Engineering Drawing, formed a special exhibit at the New Haven Public Library during the first two weeks of March.

Mr. Donald Grant, Instructor in Engineering Drawing, has prepared an ingenious chart for determining graphically the net yield on securities. The chart appeared in a recent issue of the "Magazine of Wall Street."

Professor Kirby's second lettering tablet, for teaching the vertical type of freehand lettering, has just been published by John Wiley and Sons.

MECHANICAL ENGINEERING

(*Continued from page 29*)

Professor L. C. Lichty attended the annual meeting of the Society of Automotive Engineers, held in Detroit, Michigan, from January 24–27, 1928, where he discussed methods of measuring detonation, and presented a method for computing maximum detonation pressure.

Mr. F. W. Keator has been elected Commander of the New Haven Power Squadron.

Students in the class in Experimental Engineering under the direction of Professor E. H. Lockwood have made tests of pumping engines located at plants of the New Haven Water Company during the past winter. These tests have included a 15 million gallon single stage centrifugal pump at Lake Saltonstall, and two 2 million gallon 2-stage centrifugal pumps at Lake Whitney. All the pumps were driven by condensing steam turbines, using reduction gearing.

On the evening of February 28 Mason Laboratory was the scene of a very well attended meeting of the New Haven Section of the American Society of Mechanical Engineers. The speaker, Mr. E. L. Milliken of the Belamose Corporation, gave his audience a most interesting talk on the manufacture of Rayon, tracing the history of its discovery and development and showing by two very complete movie reels the process of manufacture in use at the present time. He also brought with him a great variety of Rayon fabrics showing how the material could be used in combination with the other fibres, and bringing out the noteworthy fact that it is well adapted for dyeing in all sorts of brilliant colors. The meeting was one of a monthly series that the local section of the A. S. M. E. holds throughout the college year, and was open to the general public, including this time the ladies, who were naturally interested in the topic.

The 7th season of Wednesday evening moving pictures of engineering and manufacturing activities arranged by the Department of Mechanical Engineering especially for New Haven industries has just been completed. The six successive programs presented this year have been of unusual interest, ranging from the manufacture of carpets and wall paper to the sending of pictures by wire, the manufacture of watches and the new hydro-electric power development at Conowingo on the Susquehanna River. The attendance taxed the capacity of the hall at almost every session.

ELECTRICAL ENGINEERING

(*Continued from page 29*)

Special attention will be given to railway electrification and the New Haven Road is arranging an exhibition of its most recent motive power equipment.

The evenings will be devoted to a reception, a banquet and a theatre party by courtesy of the Department of Drama of the University.

The Connecticut Section, which is acting as host for the Convention, has as its officers Prof. A. E. Knowlton, Chairman, and Prof. R. G. Warner, Secretary.

Electrical Student Convention.

The Student Branches of the A. I. E. E. in the Northeastern District (New England and New York State) numbering a dozen or more hold an annual Convention. The first was at M. I. T. in Boston two years ago, followed by the Pittsfield Convention last year. This year the Convention is at Yale on Friday, May 11th. There will be a technical session for student papers in the morning and inspection trips in the afternoon. The latter will include the engineering laboratories and other features of Yale and a collection of locomotives of various types, both steam and electrical of latest designs by the New Haven Railroad.

Meter Tests.

Meters for the measurement of electric energy sold to customers by power companies have a variation in accuracy with temperature. Meters of recent manufacture are being compensated for temperature changes. Investigation is now being made in the electrical laboratory to determine whether a simple compensation device can be developed which will improve the performance of the older meters. This involves the employment of refrigeration apparatus and heater cabinets to establish the range of temperature over which the observations are being made.

FORESTRY

(*Continued from page 29*)

the past winter. Hon. Gifford Pinchot spoke to the Club on December 2 on the Mississippi River flood control problem, the oil scandal, and the liquor question; Prof. A. Petrunkevitch, of Yale, followed on Jan. 10, with an illustrated talk on "Spiders in Their Relation to the Forest;" D. N. Rogers, '07, Supervisor of the Plumas National Forest, conducted an illustrated and informal discussion of some of the problems of the Forest Service on Jan. 27; and on Feb. 21 Julian E. Rothery, '08, Forest Engineer for the International Paper Co., spoke on "The Possibilities in Forestry for the Young Graduate." At this last meeting of the Club, M. A. Payne, '29, and A. E. Trist, '29, were elected President and Treasurer, respectively, for the ensuing year.

20th Engineers' Memorial Address.

The eighth annual address on the 20th Engineers' Memorial Foundation, under the auspices of the School of Forestry, was given at Sage Hall on the evening of February 24 by Reuben B. Robertson, President of the Champion Fibre Company of Canton, North Carolina. Mr. Robertson spoke on "Forest and Factory," discussing some of the problems of pulp and paper manufacture. Following the address three reels of moving pictures were shown, two illustrating the logging practice on the holdings of the company and the third showing some of the processes by means of which wood is converted into pulp.

VENEZUELA SECOND IN WORLD OIL PRODUCTION

(*Continued from page 17*)

Substantial road building has been steadily carried forward together with other public improvements, and the Government engineers have surveyed and favorably recommended a deep water harbor at Port Salinas on the Paraguana peninsula, the construction of which will eventually be carried out. Sanitation, a very important subject in tropical countries, is receiving attention in the larger communities throughout the Republic. The attitude of the Government to foreign enterprises is intelligent, fair and businesslike. The larger part of Venezuelan export trade is with the United States, which naturally makes for a better understanding between the two countries.

Petroleum Laws.

The petroleum laws of Venezuela are sound and workable and reflect the businesslike attitude of the administration toward foreign capital invested in the country. The piesent laws were formulated in cooperation with the officials of American and British oil companies. All mineral rights are owned by the Federal Government and are segregated from the surface rights. The oil rights are acquired under grants known as "Exploration Concessions" on tracts of 10,000 hectares (25,000 acres), the limit to any one company being 750,000 acres, unless special permission is obtained from the Government. Three to four and one half years after the exploration concession is granted, a total area not to exceed one-half of the acreage must be selected by the holder of the concession and the remainder turned back to the Government to become part of the National Reserves. The selection of tracts to be retained (these tracts being termed "Exploitation Parcels") must be in units not to exceed 1,250 acres each, which may be checker-boarded or joined together in one large tract, provided this acreage is contiguous to the part returned to the Government. The period of concession on such exploitation parcels is forty years, counted from the date of issue of exploitation certificates. The concessionaire at the time of selecting the exploitation parcels pays the government an initial exploitation tax of approximately sixteen cents per acre and thereafter a rental is charged, which amounts to approximately sixteen cents per acre per year for the first three years of the exploitation period, on the net area of the exploitation parcels. No drilling requirments are imposed, but failure to pay rentals for three years, combined with failure to drill, constitutes grounds for forfeiture. The royalty rate is 10% of the oil produced, excepting as to lands denounced by the surface owners, or on lands 150 miles inland from the sea or lake shore, or on concessions covered by waters of the sea, lakes or navigable rivers, when the royalty is reduced to 7½%.

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Who will scout this industrial frontier?

WHETHER in the Bell Telephone Laboratories, in the Western Electric workshop, in the various operating companies or in the American Telephone and Telegraph Company, telephone executives are scouts on the frontier of new and better methods.

It is significant that your true telephone man, with the feel of the calling in his blood, never speaks of having "perfected the art of communication." And this in spite of the fact that America, in fifty years, has telephones everywhere and talks far beyond its borders.

Work in the Bell System demands the bold curiosity of pioneers and the infinite pains of pioneers who, like Columbus, Lincoln and Lindbergh, prepared "and when their chance came they were ready."

VENEZUELA SECOND IN WORLD OIL PRODUCTION

(*Continued from page 37*)

Operating Conditions.

The general conditions under which oil field operations are carried on in Venezuela are unlike those in the United States and, comparatively speaking, may be said to be more difficult. As drilling in Venezuela is in reality a pioneer undertaking, it requires the importation of all supplies and materials, as well as skilled labor, and for this reason is best undertaken by large, experienced operating companies. This condition is likely to prevail for some time to come. It naturally follows that under these circumstances it is not only advantageous but almost absolutely necessary for any oil company entering the field to have a complete, self-sustaining organization. That the administrative branch of such an organization should have a personnel thoroughly familiar with the Latin-American practices is very essential, if not vital, to its successful outcome.

Actual drilling in the formations of the Maracaibo Basin, which are for the most part soft and unconsolidated, is comparatively easy. The principal factors contributing to drilling costs are transportation and labor. Owing to peculiar climatic conditions which, broadly classified, result in a wet and a dry season, each of six months duration, the cost of drilling operations is increased. Climatic conditions require special housing, food and water supplies in order to safeguard skilled foreign labor from tropical diseases. Native labor is wholly unfamiliar with oilfield operation and while this class of labor is being successfully trained and can be developed to a reasonable state of efficiency, it will naturally require some time to bring this about. One impression which is gathered in travelling through this country is the helpful attitude of the Venezuelan Government toward the oil industries and the friendly attitude of the Venezuelan people toward foreigners.

Summary.

From the foregoing statements, it is apparent that Venezuela has experienced a very rapid growth and development of its petroleum resources during the past ten years, and at the present time is increasing its output at a faster rate than any other country. It has long passed the pioneer stage of its development and has forged its way to second place in world oil affairs. While predictions in the oil business are always hazardous, engineers most familiar with the Venezuelan operations estimate that the production of oil for 1928 will reach 100,000,000 barrels.

When the character and extent of the petroliferous provinces of Venezuela are considered, one is forced to the conclusion that the oil development of that country is still in its earlier stages. The State of Falcon and the southwest portion of Maracaibo Basin are largely unexploited, and in the Orinoco Basin, which may be said to be similar in general geologic conditions, and equally favorable for oil, but much larger, wildcat drilling has hardly started. The majority of the larger American oil companies are either operating or holding large concessions in this country. English capital, through the Dutch Shell and its subsidiaries, is also well represented in the Republic by the exclusive ownership of the districts of Maracaibo, Bolivar and Colon. Under the petroleum laws of the country, which require the return of half of the concession acreage first acquired for exploration, an opportunity will be afforded as time goes on for other companies to enter this field. Transportation facilities are improving through the construction of additional and larger lake tankers. Modern terminal sites and refineries are being built and enlarged, on the islands of Aruba and Curacao as well as on the Paraguana peninsula and mainland of Venezuela, for the transportation and treatment of petroleum and its products. Under these conditions the progress which has been made in the exploitation of Venezuelan oil resources may be expected to continue at an accelerated rate till the vast undeveloped areas of the Republic have been thoroughly prospected and the results known.

A SURVEY OF MODERN MARINE ENGINEERING

(*Continued from page 10*)

tions and rocking the ship, we map be able to back off sand bars and mud flats, if we have inadvertently landed on one!

Fire detection and smothering apparatus of a very effective type is now available and is being installed on most ships. Life-saving equipment is always installed to a degree in excess of that required by law. We are experimenting with contra-propellers, special rudders and many other devices to make the application of power and controlling forces to these huge masses more effective and precise. We have a long way yet to go in perfecting our cargo handling methods, but there are signs of progress in this important field. Ashore we have developed our form-changing machinery to a high degree but it is only recently that the place-changing machinery in our factories has begun to receive adequate study and development. On a ship this matter of stevedoring is even more closely related to safety work.

If we should develop an American Merchant Marine which is adequate for our position on the seas and if our commerce will justify the building of a fine fleet of merchant vessels, American marine engineering practice is ready to design and operate the finest type of power plants. Competition is keen and we are living in a decade when much development work is being done in order to provide the one best type of equipment for the next period.

Just as in the power plants ashore, where developments require that the personnel continuously study their equipment and processes in order to make them operate in the one best way, so we must develop a type of marine engineer who can continue to be a student and improve the operation of the equipment entrusted to him as he makes the maximum number of ton-miles at the lowest total unit-cost at sea and gives the most economical auxiliary service in port.

IMPORTANT DISCOVERIES IN GLACIAL GEOLOGY

(*Continued from page 13*)

high. A ditch cut through the eastern suburbs of Plainville, a mile long and less than twenty feet deep, would serve to direct all the waters of the Farmington and Pequabuck rivers into the Quinnipiac. And all because the broad valley in which these streams now flow was the bottom of a glacial lake a few thousand years ago. The lake was suddenly drained as a dam gave way, and on the slightly irregular surface of the newly exposed bottom, the water flowed off through the lowest channel. This channel, quite accidently, happened to be the long Farmington-Tariffville route. Once the stream began to follow and deepen it, the result was inevitable and the possibility of the shorter journey was lost for thousands of years to come.

Commercial Value of Glacial Geology.

Although glacial geology is commonly considered a pure science, the study of the glacial deposits has important bearings on modern life. The world-famous soil of the American Corn Belt owes its depth and composition to its glacial origin. Nearly all the sand, gravel and clay used in northern North America for roads, railroad ballast, concrete work, brick making and hundreds of other projects is ice-transported and comes from the moraines and the outwash of the glacial epoch. Trained geolo-

(*Continued on page 42*)

IMPORTANT DISCOVERIES IN GLACIAL GEOLOGY

(*Contnued from page 40*)

gists employed by highway departments, railroads, and large industries annually save large amounts of money by locating and directing the efficient use of glacial deposits. Further savings are effected to communities and to home owners in the intelligent use of geologic knowledge in drilling water wells in the glacial drift. Certain types of drift are productive of steadily flowing water, while others are practically barren. Glacial deposits are less important as sources of economic minerals, although a number of large and valuable diamonds have been found among pebbles in the drift in various parts of the Great Lakes Region. In Finland the finding of many glacial boulders carrying ore-minerals has led to the preparation by government geologists of detailed maps on which the location of each known boulder is accurately plotted. The boulders are seen to be arranged in irregular lines which converge toward the north. The reason for this is that the ice sheet constantly spread out laterally as it moved southward, and that bits of rock picked up by the ice from any outcrop of bedrock were carried on and dropped over a fan-shaped area south of the outcrop but of course never north of it. The Finnish geologists reasoned therefore that the convergence of the lines of boulders on the map, should lead to a northern point not far from the outcrop of the ore-bearing rock; and when this principle was applied it was found to work with success. Similar work in northern Sweden later led to the finding of a commercially important copper mine. This is only one instance of the adaptation of glacial geology to economic uses.

Age of the Glacial Period.

Geologists are often asked "how long ago was the glacial period?" The answer is that it is still going on. Ice in Arctic and Antarctic regions is probably of nearly as rare occurrence as ice in temperate latitudes. Fossil records in polar rocks tell us beyond doubt that polar temperatures are ordinarily mild. The masses of polar ice today are therefore but the remnants, slowly disappearing, of the far greater sheets which recently overspread large parts of both the northern and southern hemispheres; and we may very possibly look forward to a time some thousands of years hence when perennial ice shall have disappeared completely from the face of the earth. There are various yardsticks, all of them more or less faulty and poorly calibrated, by which we can measure roughly the time which has elapsed since the ice front last stood, say, over central New England. There are the amount of recession of Niagara Falls, which first began its backward cutting when the ice margin lay north of Buffalo, the yardstick of the banded clays, the degree of weathering of the last drift sheet, the amount of evolution of postglacial life. Estimates based on these imperfect scales range from 15,000 to 50,000 years ago, with the weight of evidence in favor of the lower figure. Sometime a genius will come forward with a refinement of one of these methods or more likely still, with a wholly new and delicate means of determining the length of glacial and postglacial time. Such means are as wholly unknown to us in 1928 as was the former existence of a great ice sheet to the people of Silliman's day.

PERSONALITIES

(*Continued from page 27*)

almost unbelievable that Thomas A. Edison wrote in the *North American Review* for November, 1889, "there is no plea which will justify the use of high alternating currents, either in a scien-

(*Continued on page 44*)

PERSONALITIES

(Continued from page 42)

tific or a commercial sense—and my personal desire would be to prohibit entirely the use of alternating current". Today about 97% of our primary electrical energy is alternating current.

Scott was active in the early development of the Niagara Falls Power Stations. He also devised the balancer system for the early alternating current railroad electrification that is used on the New York, New Haven and Hartford Railroad and later adopted for other railroad electrifications.

Often Scott's work was ahead of his time. He took out a patent on what is now called a "Synchronous booster converter". The invention anticipated the need for this device. His patent expired before power systems had grown large enough to make use of it.

Scott is deserving of the most extravagant praise for his work in connection with the construction of the Engineering Societies Building in New York. He was so eloquent in describing the need for such a building and the beneficial purpose it would serve that Andrew Carnegie donated enough money to cover almost the entire cost of the building. The following resolution is among those adopted by the board of directors of the American Institute of Electrical Engineers. "The society desires to put on record its hearty recognition of Charles F. Scott's earnest, faithful and efficient services throughout the inception, construction and completion of the Engineer's Building; resolved that Mr. Scott's engineering experience, his watchful care and his thorough appreciation of the requirements of the future as well as of the present, and especially to his controlling influence in thus bringing about the full realization of a plan which at the outset seemed only visionary, the Electrical Engineers of America are and will for all times be indebted".

It would perhaps be easier to list the engineering society that Scott is not connected with, than to name those of which he is a member. He was President of the American Institute of Electrical Engineers and incidentally was the youngest man to hold that office. During his administration the membership of the society increased tremendously. He started the practice of admitting student members to the society. He is a member of the American Engineering Council. He was president of the Society for the Promotion of Engineering Education and a member of the advisory committee of the National Electric Light Association. It would be almost impossible to list the important committees of which he is a member, in fact he might be called an "all-American" committee man.

As an educator he is unique. Unlike most men who know higher mathematics he shuns it. His individual method of attacking problems is most helpful to students. He always presents and analyzes a situation from many different angles.

His annual demonstration lecture made in the proximity of a 2,200 volt line is exciting to his audiences. His expansive gestures keep his audience on the edges of their seats as no mere words would.

Recently his friend, Herbert Hoover, offered him an important federal position.

The *Electric Journal,* today one of the leading technical magazines, was founded by Professor Scott.

Attending engineering banquets is one of his greatest delights.

His eloquence won from Andrew Carnegie the money for the construction of the Engineering Building. Few men can boast of having talked a Scotchman out of a million dollars. We haven't heard Carnegie's side of the story, but at any rate Professor Scott became convinced that speech is golden. He is a profligate with that species.

S. K. W.

HIGH PRESSURE COMBUSTION

(Continued from page 21)

The pressure of the unburned portion of the mixture which is being compressed by the advance of the flame and the expansion of the burned portion, is a measure of what is taking place. To obtain a true record of this pressure rise during combustion a special obtical indicator was developed. The principle of this indicator is simply that steel is an elastic substance, and when subjected to stress shows a definite deformation, and if not stressed too far will repeat past performance under similar conditions. The problem was to subject the indicator element to the combustion pressure and then to obtain a measurable record of the deformation.

Due to the rapid rate of pressure rise it is exceedingly difficult to design an indicator which will accurately follow and indicate the pressure. Not only must the instrument be extremely sensitive but also it must be rugged to stand these pressures. The sensitiveness is obtained by designing the indicator to have a very high natural frequency of vibration. The time period of vibration is proportional to two items:

$$t \propto \sqrt{\frac{W}{F}}$$

W=weight of the spring element of the indicator

F=the force to deflect the indicator tube a unit amount.

To obtain this characteristic of high natural frequency the force unit deflection of the indicator is made extremely high (compared with ordinary indicators) by using a tube for the indicator element, and to reduce the mass the tube is made of thin walls with re-enforcing rings. A pressure of 10,000 lb. per sq. in. in the combustion chamber, (Fig. 1) transmitted by mercury, produced an extension of the indicator element of 2½ thousandths of the inch. A system of knife edges and a beam supported on them by a piano wire stretched almost to the elastic limit transferred the extension of the indicator element to an angular beam movement. A beam of light provided the means of magnifying the few thousandths of an inch into inches. This part of the apparatus included an arc lamp, a mirror and a revolving photographic plate. A pin-hole in front of the arc provided the point source of light. This was directed at the mirror fastened to the beam on the knife edges. The mirror focused the light on the photographic plate.

The optical photographic apparatus were surrounded by a dark enclosure, a shutter admitting light at the desired time. Fig. 2 is a typical combustion record. The inner circle was made with atmospheric pressure in the combustion chamber. The gaseous mixture, which had been thoroughly stirred, was measured and compressed into the combustion chamber until a pressure of 1000 lb. was reached. At this point the second circle was made on the plate. The radial distance between the two lines represents an increase in pressure of 1000 lb.

With the plate revolving at a rate of 900 r.p.m. the combustion is started and the pressure rises from the 1000 lb. line to the maximum, which is about 8000 lb. in this record. After maximum pressure is reached cooling takes place and the pressure slowly falls, as indicated by the spiral line.

Two complete series of Hydrogen-Air experiments were made.

1. The length of the combustion chamber was varied while the initial temperature was held constant at 80° Fahr. for ten mixtures ranging from the rich explosive limit to the lean explosive limit.

2. The initial temperature was varied from 80° Fahr. to 400° Fahr. while the length of the combustion chamber was held constant for eleven mixtures from one explosive limit to the other.

Some of the more interesting results of this investigation are:

1. The heat loss to the combustion chamber walls during pressure rise varies from 10 to 25 per cent of the energy liberation, depending upon the time of rise and also upon mixture.

2. The time of pressure is shorter on both sides of the correct mixture rather than at the correct mixture.

KOEHRING

KOEHRING HEAVY DUTY

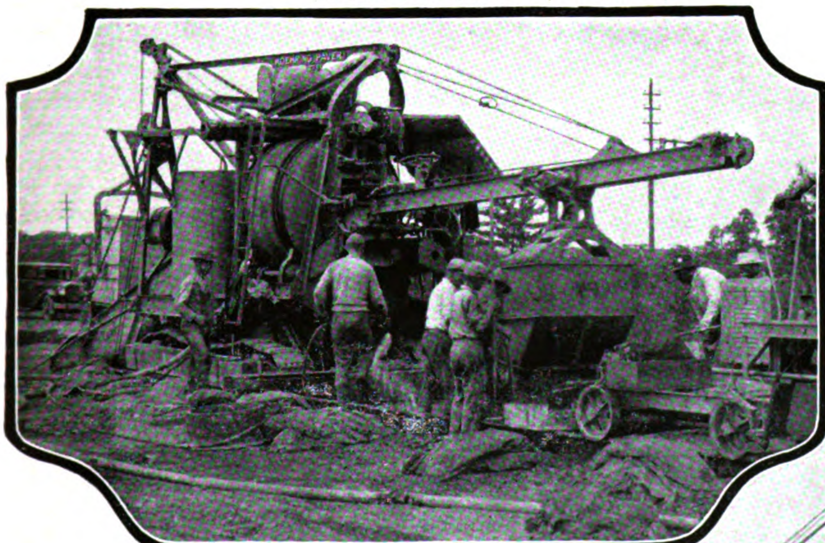
Paving the Sunrise Highway Long Island

LONG Island, New York, will have a concrete highway, forty feet wide, the full length of its one hundred and twenty-five miles, stretching from Queensboro to its eastern tip, off the Atlantic seaboard. This modern thoroughfare has been named "Sunrise Highway", and when completed, will exemplify another step in America's progress toward adequate traffic facilities.

Three Koehring Heavy Duty Pavers were used in paving the first sixteen-mile section, which leads east from Queensboro. Dividing this sixteen-mile unit into three parts, a Koehring Paver was placed on each, with proper material-handling equipment to accompany each paver.

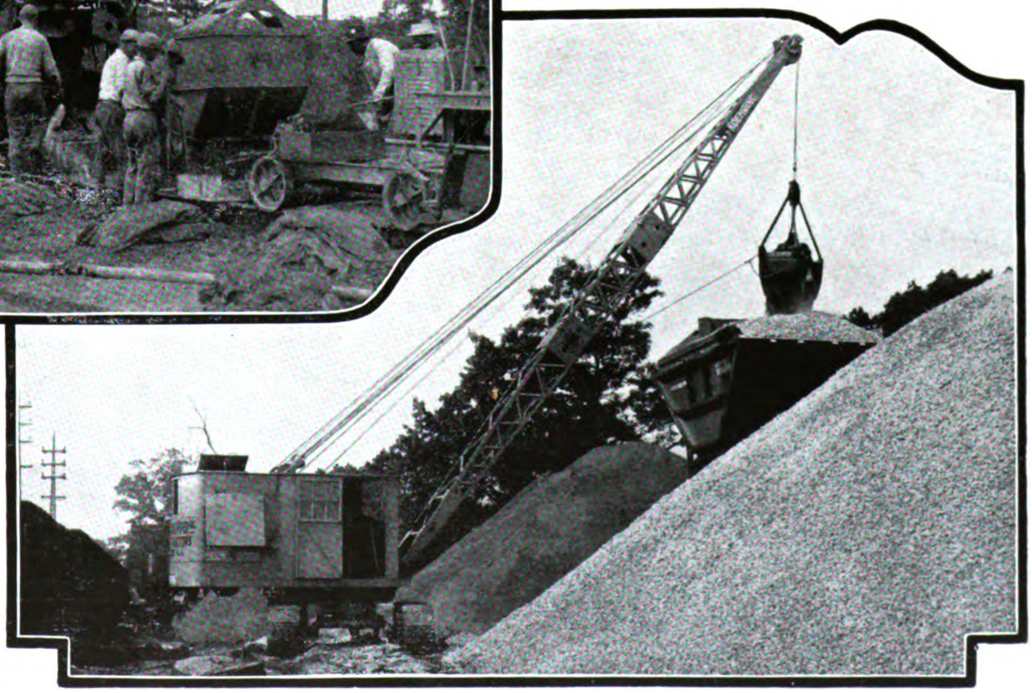
To further eliminate chances of costly delays, two Koehring Heavy Duty Cranes were used in handling the sand and gravel at the proportioning plants. Thus, through careful selection, the contractor built up dependable paving units which would hasten the completion of this important section of the new Sunrise Highway.

Such organization of Koehring Heavy Duty equipment in highway construction is not unusual—it may be found in almost every state in the Union and in many foreign countries. The contractor-engineer, the world over, recognizes the value of dependability.



KOEHRING COMPANY
MILWAUKEE, WISCONSIN

Manufacturers of
Pavers, Mixers—Gasoline Shovels, Cranes and Draglines



The revised edition of "Concrete—Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, is now ready for distribution. To engineering students, faculty members and others interested we shall gladly send a copy on request.

The Best "Line" on Any Car—

The presence of Timken Bearings *is* an accepted sign of excellence in motor cars. How soundly can the public judge in this way? Some recent tests by car manufacturers, entirely in their own interests, are very illuminating. It was found that one factor—Timken Bearings!—made the pinion mounting, for example, *twice as resistant* as otherwise to the chief causes of wear and noise!

Responsible for such results are the extreme rigidity, the high load area and full thrust capacity made possible only by Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS*, and Timken-made electric furnace steel. This exclusive combination gives Timken Bearings the thrust-radial capacity by means of which they establish new endurance and economy records where anti-friction bearings have been thought "impossible."

Timkens sweep on not alone in motor cars, but in railroad trains, in electric motors of every type, in rolling mills, and in such precision applications as machine tool spindles. Every engineer is having more and more to do with Timken Bearings.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* BEARINGS

QUINNIPIACK PRESS, INC.
NEW HAVEN, CONN.

THE YALE SCIENTIFIC MAGAZINE

VOL. II MAY, 1928 No. 4

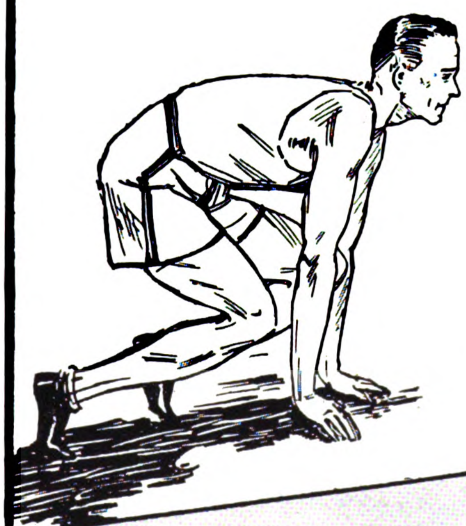
ESKIMO CAMP WEST OF HUDSON'S BAY

Dr. E. M. Kindle, Chief Paleontologist of the Dept. of Mines, Ottawa, Canada, discusses the vast possibilities of development and settlement in the Dominion, north of 56°. *(See page 7)*

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL

PRICE FORTY CENTS

This race called ~ *BUSINESS!*



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You are soon to take your place in this race called . . . . **business.**

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THE YALE SCIENTIFIC MAGAZINE

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SCIENCE AND ENGINEERING IN MODERN EDUCATION

Where do Science and Engineering belong in modern education?

The struggle of the pioneers of Science to get a foothold in the classical Yale of 80 years ago is told in the story of the beginnings of the Sheffield Scientific School. It was a struggle against an ignorance or prejudice difficult for us to understand, now that Science is no longer an intruder but has won its place.

Try to picture the awakening today of a Rip Van Winkle of four score years. Everywhere he turns he finds a new world. And it is a new world which Science has brought about. Not only are the material aspects of living different but there are new methods of thought and a new outlook on life—it is a Scientific Age. New intellectual forces have come into action and have become the dominating forces.

Aside from the education of pure scientists and technical engineers is the question of including pure and applied science as a part of the education for other fields of life. The social sciences and the humanities are dealing with man's reaction to his environment both in action and thought. These are being tremendously affected by the material developments of Science and Engineering. Not only should engineers have more concern as to the ultimate results of their activities but likewise those who are devoting themselves to social and human problems should concern themselves with the material factors which are changing social conditions. Undergraduate student interest is awake to its importance.

"Science Shunned" was the heading of an editorial on May 4th in the Yale Daily News. It is so significant to Yale and to science that the Yale Scientific Magazine commends it to its readers. In condensed form it is reproduced here.

"Dissatisfaction has been evinced by candidates for the B. A. and Ph. B. degrees as a result of the rigidity of the college requirement that at least two full year Science courses be elected. The trouble is not so much from the regret of devoting valuable time to subjects not relevant to the pursuit of the arts, but from the profound discouragement which they have met in the methods by which the Scientific courses are taught. The remark is often made that the departments of Science take it for granted that every student in an elementary course is becoming 'grounded' in the work, preparatory to becoming a specialist, which is obviously far from the truth. What many really desire is a thorough introduction to the elements of scientific thought and the chief principles in the scientific method of approach; and under the circumstances this desire is impossible of gratification. With Science holding its position of vital importance in relation to economic, sociological, and governmental affairs in the world today, it is not unfair to say that it should be treated from an angle which would stimulate rather than discourage the interest of the student".

"Engineering is also Shunned" was the title of a communication by Professor A. E. Knowlton in the News three days later. In condensed form it is as follows:

"It is principally the realization of that same deterrent of abstract factuality of content that has resulted in a very minimum of engineering courses open to candidates for A.B. and Ph.B. degrees. But this does not seem to be an insuperable obstacle.

"One does not need to delve deeply into the intricacies of, say, magnetic phenomena to sense the economic meaning of the fact that one-third of all the new-capital financing in this country last year was devoted to enlarging the nation's power systems. Nor does one need to attempt expertness in the design of electrical apparatus to be able to see the effect of electrically-driven machinery upon wage scales, savings, recreation, industrial contentment, social well-being of the American industrial worker. Nor need one be fortified with several brands of mathematical ingenuity in order to trace the progress of the electrical age from the days of the pioneering physicists and chemists to the present epoch in which civilization is so completely dependent upon electrical systems for power, light, communication and much of its transportation.

"There does appear great need for a presentation of science that will avoid the presumption that the student is bent on specialization. The tone would rather be to interpret the part that engineering science has played in developing new concepts and new problems in the fields of finance, banking, goods production, goods transportation, industrial sociology, social welfare, standards of living, government, legislation, conservation of resources, etc. It needs no prophet to discern that agencies which have been so potent in the past and are extending so rapidly now will have a larger significance in the future".

Canada North of Fifty-six Degrees*

The Land of Long Summer Days not as Harsh and Forbidding as Commonly Painted—Great Possibilities for Settlement and Development

DR. E. M. KINDLE
Geological Survey of Canada

NORTHERN lands have in the past been held in small esteem by the general public. A somewhat comparable failure to appreciate mountain scenery during the Middle Ages and earlier led men to avoid the Alps and other mountain regions of Europe which later became the playground of that continent and much of the rest of the world. The deep-rooted prejudice against Arctic and sub-Arctic lands enabled a few far-sighted Americans to acquire for the United States some sixty years ago the vast territory of Alaska for a sum less than the value of ten years' output of the Nome beach gold field, discovered twenty-five years later. In Europe, however, the old view that lands of the Far North are worthless is rapidly passing. Evidence of this is seen in the fact that Norway has acquired sovereignty over the large Arctic island of Spitzbergen and is developing its rich coal deposits and fisheries. The eastern coast of Greenland may be fairly called the most inhospitable land in the Northern Hemisphere. Only very skillful navigators can penetrate through the ice fields to the coast in midsummer; yet the ownership of this frigid coast, with its ice cap on land and nearly impenetrable floes on the sea, has recently been the subject of a long and rather bitter controversy between the Norwegian and Danish governments. A colony of west coast Greenlanders has lately been successfully established by Denmark on the ice-blocked east coast of Greenland.

The region which is here discussed has no precise boundary, but it may be defined in a general way as that part of Canada lying north of the present northern frontier of settlement. The northern border of this frontier is manifestly a highly irregular line which moves northward under the control of a variety of influences, among which are topographic features, climatic conditions, railway development and the dissipation of erroneous conceptions of northern Canada. The average position of this line in western Canada is near the 56th parallel of latitude.

The Author at Great Slave Lake.

Northern Canada was long regarded as a fit abode only for fur traders and Eskimo. The fur trade was considered its only asset until some twenty-five years ago when the Klondike River Valley began to pour out its flood of gold. The discovery, since the early Klondike days, of various other notable but less spectacular Eldorados near the northern frontier has led Canadians to revise their earlier valuation of their vast unoccupied and almost unknown heritage in the great Northwest. But the opinion still widely prevails that northern Canada is a desolate barren land of snow and ice which has little to tempt anyone but the prospector and the trapper.

The man who always searches for the worm in the apple, while granting that the prospector, miner, or fur trader may be willing to spend a few years in Northern Canada in the hope of winning a fortune, will deny that any highly developed social organization or large population can ever be expected in a land almost deserted by the sun in winter and which lies hundreds of miles north of such population centres as Winnipeg and Edmonton,—where the temperature falls about as low as the ordinary man cares to endure.

It must of course be admitted that the winter evenings are long and the hours of daylight few in winter north of lat. 56°, and any enquiry into the resources of northern Canada may well begin with a consideration of this oft-cited bar to their development. The superb health and vigour of the northern Eskimo afford conclusive evidence that the long winter nights have no harmful effects. The Eskimo looks forward to the dark midwinter period as a time for long visits to friends, and spend it in singing, dancing and social

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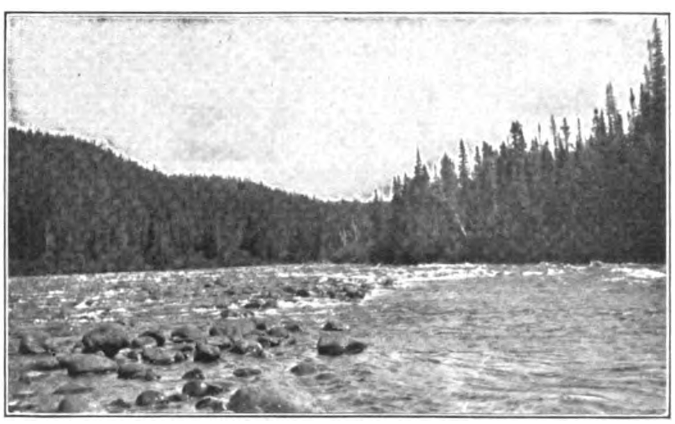
* ED. NOTE.—This paper represents an abridgement of a much longer manuscript dealing with the geography of Northern Canada which is published in the current number of the *Canadian Field Naturalist*. It was awarded the prize of $1,000 for the best discussion of the geography and resources of Northern Canada.

pleasures. After ten winters in the Arctic, Stefansson reports the darkness of Christmas to be "about as depressing on the northern coast of Canada as the darkness of midnight on Broadway".

It might be claimed, however, in spite of the gay winter life of the Eskimo, that the long dark winter evenings would lead to mental stagnation in any white race which dwelt long in high latitudes. The sub-Arctic island,—Iceland,—gives decisive evidence on this point. The history of the Icelanders clearly shows that the long winter nights have just the opposite effect and by giving ample time for study and reflection greatly stimulate the intellectual life. Some of the old Icelandic sagas, written centuries before the days of Chaucer, are models of style. Many of these remarkable literary productions were written when all Europe was in the deepest barbarism and ignorance. It is reported on good authority that during the last hundred years no nation can show so large a proportion of literary men as Iceland. If we can judge from the record of Iceland for the last thousand years, nothing more serious need be feared from the effect of an Arctic environment on a people than the development of an uncommonly large percentage of poets.

The climate of northern Canada from some points of view is one of its greatest assets. The winter temperature in Arctic



Black Spruce Forest, Lake Melville, Labrador.

and Sub-Arctic Canada will always discourage the immigration of the negro and other tropical races as unmistakably as it does the growth of bananas. It will, on the other hand encourage the emigration of the Nordic races of Europe and raise the deterring hand to the leisure-loving races, whose motto is *Mañana* (tomorrow). Canadian climate thus automatically selects the class of emigrants which the United States has recently attempted to secure by discriminative legislation.

Anyone with an intimate knowledge of climatic conditions in northern Canada is aware that its reputed severity has been,—as Mark Twain once said of his reported death,—greatly exaggerated. The popular misconceptions are so deeply rooted that it will require decades of education to eradicate them. It is almost universally believed by those who have made no special investigation of the matter that winter climate increases steadily in severity as the north pole is approached. This is about as far from the truth as would be the assumption that the rainfall of any region is proportionate to its distance from the sea coast. The old assumption that the North Pole and the pole of greatest cold were coincident has rather recently been shown to be as erroneous as the early idea that the magnetic and geographic poles were identical. Even as far back as the fifties of the last century, when Dove's charts of the isotherms for the northern hemisphere were published, it became evident that the North Pole and the pole of maximum cold were probably separated by a considerable distance.

It was observed long ago at Kola in Lapland that a north wind always caused an immediate rise in temperature. Baron von

Indian Tepee, Peace River Valley.

Wrangle records that at his winter quarters at Nishne Kolymsk the temperature rose in winter with north winds. Dr. Kane noted the same fact at Renssalaer Harbour in Kane Basin, North Greenland. The most interesting feature connected with Captain W. E. Parry's temperature observations in the Arctic archipelago is the reported rise of temperature with a north wind.[1] The temperature records of Captain Parry,[2] who wintered at Melville Island a century ago, show the lowest temperature reached to have been 55° below zero, while northeastern Montana is credited with a minimum temperature of —68°.

Facts of this kind do not appear so surprising since it has become known that the cold pole of the world is located at Verkhoyansk, Siberia,[3] about 1,400 miles south of the North Pole, where the mean winter temperature is —48° in January. It is interesting to note that even at this coldest point in the world barley sometimes ripens and vegetables are grown in a small way.[4] To Canadians, the most interesting and satisfactory feature of

Fish Drying Shanties, Great Slave Lake.

this latest information concerning the pole of maximum cold is the fact that it is located neither in Canada nor at the geograph-

[1] Three voyages for the Discovery of a northwest passage from the Atlantic to the Pacific and narrative of an attempt to reach the North Pole. Vol. 1, p. 147.
[2] Op. cit., Vol. 1, p. 169.
[3] Danckwortt, F. W.—Sibirien und seine wirtschaftliche Zukunft: Win Ruckblick und Ausblick auf Hendel und Industrie Sibiriens (1921). Geogr. Review, Vol 13, p. 314, 1923.
[4] Zenzinov, Vladimir M.—With an Exile in Arctic Siberia: National Geographic Magazine, Vol. XLVI, p. 701, Des. 1924.

ical pole but in Siberia. After the school geographies have had time to assimilate and broadcast this information, the popular mind will be prepared to look upon the future development of northern Canada from a new point of view.

A clear perception of the fact that latitude is a factor but often the least important one, in controlling temperature is fundamental to any adequate evaluation of the potential resources of Arctic Canada. The following data derived from authentic sources should make this perfectly clear. The minimum temperature at Bernard Harbour, Arctic coast of Canada, in Lat. 68° 24' N. for the winter of 1915–16 was —46°[1], or two degrees milder than the temperature at Fort Simpson, 550 miles to the south of Bernard Harbour. This Bernard Harbour minimum temperature is only one degree colder than the lowest temperature recorded for New England during a 30-year period preceding 1918 and the same as the lowest temperature observed in northern New York for the same period.[2] The comparison of Arctic coast temperature records with those from the interior of Arctic America makes evident the relatively mild character of the winter climate of the coast. The lowest temperature recorded at Point Barrow, Arctic coast of Alaska, during a period of 5 years was —50° while a temperature of —76° has been observed at Fort Yukon, 340 miles farther south, where the temperature mean for the entire month of December, 1917, was nearly 49° below zero[3]. The minimum temperatures[4] recorded for the year 1900 at Herschel Island at the mouth of the Mackenzie, McPherson 130 miles, and Good Hope 270 miles south of Herschel, were respectively —49.4°, —60°, and —62°, increasing in severity, it will be noted, from north to south as in the comparison between Point Barrow and Fort Yukon in Alaska.

Colorado claims to have a lake near the 40th parallel some 600 miles south of the Canadian border which is free of ice only one

Indian Birch Bark Canoes, Mackenzie River.

month in the year.[5] South Dakota has a minimum temperature record of 50° below zero.[6] The important fact to remember, however, in connection with the —50° temperatures of South Dakota and Northern Canada, is that all continental climates run to extremes. With a record of 50° below, South Dakota can some years indulge in tennis at Christmas, and the towns of sub-Arctic Canada and Alaska enjoy every winter the sport of dog races which sometimes cover a 300 or 400 mile course.

The summer climate of northern Canada is apt to surprise even well informed travellers who cross the Arctic Circle via the Mackenzie River for the first time. This is well illustrated by the testimony of Mr. Elihu Stewart, formerly Superintendent of Forestry for Canada, in his book "Down the Mackenzie and Up the Yukon". "We had counted on escaping the usual July

Wooyak or Women's Boat, Arctic Coast.

heat", Mr. Stewart writes, "but for the greater part it had really been more oppressive and certainly more constant, extending right through the long twenty-four hour day, than I had ever before experienced." Another author speaking of his experience northeast of Great Bear Lake writes that all of his party agreed, "We had never in our experience suffered as much from cold as we suffered from heat that summer". Ample confirmation of the impressions which the traveller in the North gets of the summer climate is furnished by the Weather Bureau records at Fort Yukon, just at the Arctic Circle, where temperatures above 90° in the shade are recorded nearly every summer.

Even in the old Eskimo legends we find allusions to the summer heat. A legend concerning the contemporaneity of the mammoth and the Eskimo illustrates one method of escaping the heat resorted to by the natives. According to this old tradition, as recorded by Dr. J. B. Driggs,[1] a hunter finding the weather extremely warm "sought the shelter of a cave, intending to await the passing of the heat of the day. He had not been long in the shelter before the sound of a heavy animal passing rapidly over the earth greeted his ears, and on looking out he saw a mammoth in full flight, the huge creature exhibiting great fear as it was being chased by a thin, short-haired wolf".

The "frozen north" has for a number of years been retreating northwards. Like the "great American desert" which constituted the major portion of the United States west of the Mississippi River, according to the geographies of sixty years ago, the "frozen north" is destined to shrink to very small proportions.

Settlement.

If the growth of population in all parts of Canada is a desirable thing, there is no part of the Northland which needs more to be brought to the notice of the public than the Arctic coast and the region northwest of Hudson bay. If it can be demonstrated that large settlements of the white race can live in that region as contentedly and happily as the Eskimo do, the vacant

[1] Johansen, F.—Vegetation along the Arctic coast between Point Barrow and Bathurst Inlet: Can. Arctic Exped., Rept., Vol. V, Pt. C (MS.)
Anderson, R. M.—Recent Explorations on the Canadian Arctic Coast; Am. Geogr. Rev., Vol. 4, p. 258, 1917.
[2] Memo. from U. S. Weather Bureau.
[3] Op. cit.
[4] Preble, E. A.—North American Fauna, No. 27, p. 35, 1908.
[5] Robert S. Yard—Glimpses of our National Parks, Dept. of Interior, Washington, p. 10, 1916.
[6] Freeman Ward—Geogr. Review, April, 1927, p. 245.

[1] Driggs, John B.—Short Sketches from Oldest America: Geo. B. Jacob & Co., Phila., 1905, p. 83.

lands to the south will fill up fast enough to put our frontier railroads on a paying basis at an early date.

Professor O'Neill, after describing the climate of the Arctic coast, where he spent two winters writes:[1] "It may be seen, then, that as far as the climate is concerned, there is nothing to prohibit settlement. Game and fish abound and there should be little difficulty in establishing a mining industry if the mineral deposits prove to be valuable. Underground mining could be carried on throughout the whole year without much inconvenience."

Dominion Experimental Farm, Beaver Lodge, Alta., Showing a Fine Field of Oats Grown Near Latitude 56°.

The lowest temperature recorded during his second winter on the coast was —44°. The minimum temperature for the same season (1915–1916) at Edmonton was —45°. Conditions which appear to decidedly encourage settlement on the Arctic coast are stated by Professor O'Neill as follows: "The sun is quite hot in April, the seals come out on the ice and the caribou begin their migration to the northern islands. In May, the wild-fowl arrive and after them the small birds; the sun shines for twenty-four hours and the vegetation responds rapidly, so that by the middle of June many wild flowers are in bloom, the slopes and the valleys are green and small animals are seen everywhere."

"Waterpower in abundance for mining operations and probably enough to take care of local transportation, is available from Coppermine, Tree and Hood Rivers. Coppermine River, at Bloody Falls, is sometimes open all winter."

The ground is free of snow for three or four months in the year. Timber for building purposes is available at various points in the river valleys near the coast. Driftwood is common at many points on the coast. Coal is available in two or more of the adjacent Arctic islands on Horton River and elsewhere inland.

All of the evidence indicates the Arctic coast of Canada to possess a climate subject to fewer extremes of temperature than northern Ontario or the Prairie Provinces. Summer frosts may be expected, but they are by no means unknown or even rare in the country between Sudbury and Porcupine, a region long ago demonstrated to be suitable for agriculture.

However encouraging reports concerning the climate, fisheries, minerals and grazing conditions may be, settlement of the Canadian Arctic will be long delayed unless the first settlers are introduced from other Arctic lands. Settlers from northern Norway, Sweden and Finland would be almost certain to make contented and successful colonists in the Canadian Arctic because they would find a climate and environment nearly identical with those to which generations of their ancestors have been accustomed. The introduction and development of reindeer herding may be regarded as an important and necessary feature of the settlement of parts of northern Canada.

The northerly limit of settlement in Canada need not be and will not be dependent on the climatic limitations of agriculture any more than it is in Norway. North of Trondhjem in Norway, located near latitude 63°, as the land becomes hostile to cultivation the people turn to the sea for their living. Even the farmers there live largely on fish; and when root crops fail or prove inadequate, the cattle are made to accommodate themselves to fish offal.[1] The coastal strip of Norway as far north as Hemmerfest in latitude 71° has a population of 120 people for each linear mile.[2] These facts afford some intimation of the large population which the vast sea-coast line of Arctic Canada could, and at some time will, support.

The lure of gold in the Yukon basin will probably result in many additional widely-spaced settlements and mining camps when the prospector has had time to locate the Eldorados which await discovery in the extensive mountain region between the Yukon and Mackenzie River valleys. Perhaps no better method of stimulating and increasing the results of the prospector could be devised than extra-mural courses or extension lecture courses for prospectors by western universities.

Into the vast unoccupied area in northwestern Canada between the Peace and Liard rivers the stockman and farmer will probably move rapidly enough when the opportunities and possibilities offered by the region are widely known. The lowlands around Great Slave lake, the valleys of the Slave river and the Upper Mackenzie will eventually develop as an agricultural region. In eastern Canada the farmer will gradually extend his conquest northward around the shores of James Bay.

The Canadian Government has wisely established experimental farms at different points on or near the present northern limit of settlement. In one case—Fort Simpson, in latitude 64° 40'—

Potato Field, Beaver Lodge, Alberta.

the experimental farm is hundreds of miles north of the present agricultural frontier. Some of them, like the Vermilion station on Peace River in latitude 58° 30', have been maintained long enough to demonstrate just what are the agricultural possibilities and limitations of the region near them.

The settler from the south will find Autumn a most delightful season in James Bay basin and in the basin of the Mackenzie. The birch and poplar of the forests put on the same festive colours which delight the eye farther south in October. In the north, Autumn is ushered in by nightly displays of the Aurora. The

[1] O'Neill, J. J.: Canadian Arctic Expedition, 1913-1918, Vol. XI, Geology and Geography, p. 72A, 1924.

[1] Vallaux, Camille: *Geographical Review*, Vol. XIV, p. 512, 1924.
[2] Vallaux, Camille: *Op. cit.*, p. 647.

(Continued on page 36)

On Finding One's Place in the World

Some Suggestions on Solving the Imminent Problem of Finding a Vocation for which One is Best Fitted by Training and Inclination

MEREDITH B. WOOD

ONE of the most difficult problems of life is that which presents itself to the newly made engineer, sheepskin in hand, as he sets forth to make his contribution to the work of the world. That there are so few sign posts set up to guide him along easily to the solution of this problem shows how little mankind really knows. The problem, of course, is to find out the type of work and the opportunity for which a man's education and training qualify him.

Fortunately the engineering student has given some thought to this problem in a more definite way than his academically trained brother, yet far too many young engineering graduates find themselves thrust into industry without any very definite ideas of their abilities or qualifications. They take, sad to relate, the first openings that offer, regardless of whether such openings are really what they want. Often they find out months or even years later that they are "barking up the wrong tree" and that valuable time has been wasted. How much better to give the matter a little serious and intelligent consideration at the very start by looking over the various fields and seeing where the most likely roads to satisfaction may lie. A little such planning may save years of regret, for upon the satisfactory solution of this problem depends largely a man's happiness and success in life.

The second stage of this competition is also in evidence although it has lagged somewhat behind the first, and that is the severe scrutiny to which distribution methods are being subjected. Why should it cost 50 or 60 cents to deliver a product to the ultimate consumer when it cost only 40 cents to produce it? Distribution costs too much. We have built up an unwieldy system of distributing organizations which has worked in the past, but which costs too much for present-day needs. It is to this problem that executives are turning their serious attention, and it would be well for able engineers to bring some of their methods to play in the solution of it, for it is in this field that the greatest economies of the future will be worked out. As an example of the new methods that are being evolved in the distributing field, witness the growth and success of the chain stores with their mass buying and mass selling. Witness the numbers of small retail establishments that are being forced to the wall.

The above is written to give young engineers the idea that there is still plenty of room ahead and that their futures are what they make them. Today, as in the past, success is earned by the sweat of a man's brow. The roseate-hued world may exist some place, but surely if it exists now it is the rosy hue that comes from a man's effort and not from some God-given etherial heaven. There is no short cut to success, and the sooner this is realized the better it will be for the individual.

One thought more, and that is to suggest that it might be well for the young engineer to give some attention to the direction in which our much-vaunted civilization and scientific method is taking us. Science has given us wealth and material comforts, but it can never bring us happiness. We can organize and reorganize to our hearts content, we can introduce the most revolutionary economies and methods, but after all this is done, what have we got? If I am not mistaken the world is becoming tired of so-called "material progress" which seems to give us plenty to eat and not much reason for eating. Indeed, such "progress" may lead to spiritual stagnation unless the oncoming generation asks "why" as often as it asks "how." Many years ago the Galilean stated a truth which holds today as much as it ever did then: "Where there is no vision, the people perish." As part of this vision we should be aware of the man working next to us, whether he be of high degree or low, for unless we look out for his welfare, as well as our own we will not find a lasting satisfaction for ourselves. And when we start out on this track, we will find that business and industry needs a very thorough reorganization, one which will take many, many years to accomplish.

Viewing as we do at the Yale Graduate Placement Bureau the efforts of hundreds of men in solving this problem (and sometimes failing to solve it) for themselves, we have arrived perhaps at a few principles that may or may not be helpful. The experience of those who have faced the situation successfully should be helpful to others if it is intelligently adapted to individual needs. Now what are these principles?

Three Important Principles.

In the first place, as we mentioned above, it is well to survey the possibilities that are offered in industry and in business. Thoughtful discussion with some older man in whom one has confidence is always advantageous. He probably knows the trends in business, the requirements of different fields and may be able to point out pitfalls to be avoided. Too much advice is of course of little advantage as it hinders the making of a proper decision. Always, the decision should be made by the individual, not by his family or friends.

Next, when an opening appears with a concern which looks attractive, a frank discussion is advisable with the prospective employer, to find out what he expects of you, how fast one is apt to progress, granted reasonable ability and industry, and also along what lines of development progress is possible. Such discussions are generally welcomed by the broad-gauged employer, for he realizes that frankness leads to more efficient work from the new member of his organization.

Thirdly, it should be realized that industry or business will present itself for the first one or two or three years in a bewildering set of disconnected experiences, none of which seem to indicate much progress toward the ultimate success most of us are striving for. We are set to doing apparently unimportant and trivial tasks in monotonous repetition, tasks which it would seem as if any untrained person could do, without asking a trained engineer to do them. The first years then may seem a bit tiresome and meaningless. Yet they must be gone through, for the "bottom of the ladder" in industry is just as essential as the fundamentals of tackling and passing are to the football star. Tedious, yes, but invaluable. Furthermore, the man who does these tasks intelligently will be first to get on to something of greater interest, for even in routine of this kind there is ample opportunity for suggestion and improvement. Here as always, it is through the wise use of suggestion that progress lies.

A Shaking Down Process.

But in this process, the young engineer should be keenly studying and reviewing the question of where he wants to go. (This process incidentally should be continued throughout life.) Is his present connection one which leads on to something better ahead? Are the positions before him what he really wants? If not he will wake up some fine day to find he is advancing to a type of work that is distasteful and he may find it difficult to change to what he wants. This is fact, not theory.

Suppose he is a mechanical engineer employed in pure production work. Is he fundamentally interested in making "things", in turning out finished goods, in reducing costs, in devising better methods of producing or is he more interested in "people" and their problems. If the latter perhaps he had better work into management, the handling of men, or to sales, where he will naturally be brought into daily contact with business men and their problems.

As soon as a man sees *clearly* that his present connection is not leading to the type of work he wants, we advise strongly that he face the facts squarely and do whatever the situation may demand, even if this means a reduction in income for the time being. Does this mean that a man should quit his present connection right off? Not necessarily. First he should thoroughly exhaust the possibilities of his own organization. Most concerns know the advantage of giving their employees the type of work they want insofar as this is possible. Probably a frank talk with those in authority will enable a man to gravitate gradually to the work he likes. If this does not eventuate, then he must start a search for something more to his liking. In such a situation courage is an essential and always facts must be faced.

Thus the first few years in industry should be devoted to a shaking down process, a process of adjustment where a man tests himself out and finds out what he can do and what he likes best. Not that there is any one thing that is best nor that we can ever hope to find the ideal, for even in the best of positions from Plant Superintendent to the President of a large corporation, there will always be plenty of drudgery and detail. Yet to the degree that a man finds his own type of work for which he is qualified depends largely his happiness and future security.

One important consideration is getting the employer's viewpoint. The young college graduate is frequently criticized and rightly so by business men because he expects to be advanced as rapidly as he is ready for greater responsibility. Perhaps he should be so advanced in theory, but unfortunately it does not work out that way in practice. Rather is it a question of advancement when he is ready, provided the opportunity arises.

An Age of Intensive Competition.

Now as to the years ahead, what do they offer? Are there as many opportunities as in the past or are they diminishing? Probably the answer is that there are more opportunities for able men, but they are of a different kind. The problems of the past were largely of a development nature, learning *how* to produce the kind of goods that were desired. This kind of problem naturally exists today, but with it is the difficult problem of producing with the maximum of efficiency. Today we are seeing an era of terrific competition. Great plants lie at hand equipped to produce in vast quantities, quantities so great that the public does not feel like buying all that can be produced at current prices. Naturally this equipment cannot lie idle, as that would entail great loss. The result is an ever increasing battle for markets, a battle predicted a few years ago by a number of far-sighted business men. The first stage of this competition is now well under way with factories in fairly full production, with sales spread over a wide area, but with the margin of profit reduced to very small figures. Sales prices have been cut to bring in the orders and to keep the wheels turning. As a result, executives are figuratively and literally burning the midnight oil striving to evolve more efficient methods of production, installing labor-saving machinery, originating new methods, saving pennies here and there all along the line. Hence the present demand today for the capable industrial engineer and the man of originality and executive ability who can effect economics. Hence the present trend of reorganization and consolidation. Hence also the present-day talk of unemployment, even though the wheels of industry seem to be turning at a rapid rate. There is unemployment, but not for the man of ideas, the man who is unafraid of new methods and hard work.

HONOR STUDENTS PERMITTED TO SPECIALIZE

Sheffield Scientific School to Allow Superior Students Greatest Freedom in Their Chosen Field

The annual report of Dean Charles H. Warren, of the Sheffield Scientific School of Yale University, makes public the fact that the Faculty of the Scientific School has voted to permit students of exceptional ability and promise to devote themselves exclusively to the subject which particularly interests them, if they elect to do so.

"By vote of the Faculty," Dean Warren says, "each department of study has been authorized to make such special provision as it considers appropriate and finds practicable in each of our courses of study for those students who in their judgment show exceptional ability and promise. They may assign them special work, admit them to advanced courses, or provide opportunities for research work. In science and engineering courses this will be feasible mainly in the two upper years, when the necessary fundamentals, such as mathematics, etc., have been mastered. It will enable such students to enjoy the greatest freedom possible for progress in their chosen field in proportion to their superior powers. While the majority of such students in general will wish to elect a certain number of cultural or general studies, there is nothing to prevent the gifted student after his Sophomore year from devoting himself exclusively to Chemistry, for example, or Physics, if he elects to do so, and if the department concerned can provide the opportunity.

"While these modified programs will not be specifically designated as honors courses in the exact sense in which that term has been used in Yale College, and while it has not seemed desirable to restrict admission to these privileges to men who have attained a certain arbitrarily fixed scholastic average, we aim to provide the same great opportunity to the exceptionally endowed student that the honors course is intended to offer. As a matter of fact, it is true that although we do not advertise to restrict our special science or engineering courses to the superior students, we have for some years definitely discouraged men of mediocre ability and promise from continuing in them and have transferred them, unless they were so low as to be dismissed, into the more general courses."

Beginning next fall, the Sheffield Scientific School will offer a newly arranged program of study in Physics leading to the degree of Bachelor of Science. A similar arrangement has been made in the Mathematics Department which will permit mathematics to play a predominant or major role in the science or engineering courses.

Some Pages From Old World Prehistory

The Prehistoric Era Affords to the Geologist an Interesting Study of Our Earliest Ancestors and the Beginnings of Culture and Industry

DR. GEORGE GRANT MACCURDY

WHAT is prehistory? The term "prehistoric" was first used by Sir Daniel Wilson in his book "The Archaeology and Prehistoric Annals of Scotland" published in 1851. Since then it and the noun from which it is derived have become household words. Natural history deals with the story of animals in general as well as of plants. In history and prehistory, a single genus of the animal kingdom—man—occupies the center of the stage. His life on earth is divided into two great eras: one immeasurably long, known as the prehistoric, and one relatively short, called the historic.

Members of the American School of Prehistoric Research Uncovering a Spread of Mammoth Bones and Paleolithic Artifacts in the Loess at Dolni Vistonice, Czechoslovakia. Aurignacian Epoch of the Cave-Art Period.

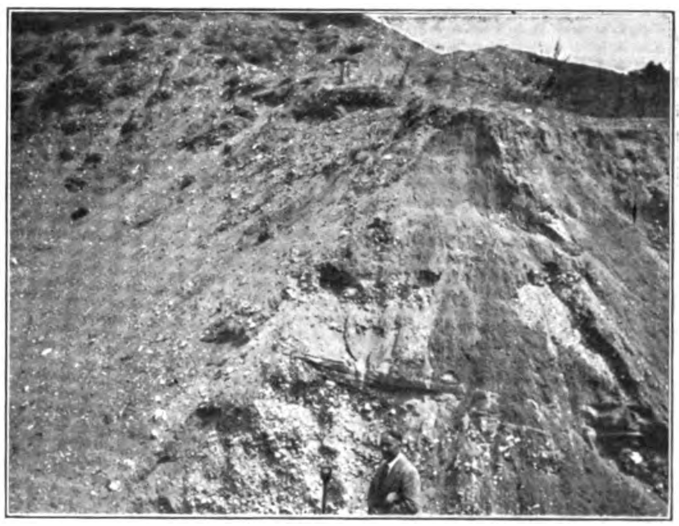
In attempting to trace the chronologic and geographic limits of prehistory, certain basic facts are disclosed. In the first place there is probably no considerable area anywhere on the face of the earth, with the possible exception of the circumpolar regions, which does not have its background of prehistory. This means that prehistoric man spread over the entire habitable globe and was either already there when historic man arrived, or had been there and disappeared before the appearance of historic man. Secondly, the greater part of the land area in each hemisphere lies north of the equator and the land area of the eastern hemisphere or Old World is much greater than that of the western hemisphere or New World. Thirdly, man appeared in the Old World before he did in the New World and the historic era is likewise longer in the Old World than in the New. In the fourth place, the earliest scenes in the human drama are inseparably linked with the Ice Age.

It was a fortunate circumstance that gave our ancestors their first foothold in the Old World. The land mass was not only much greater there than in the New World, but the area covered by the ice of each glacial epoch was also proportionately much less; that is to say, the great continental ice sheets reached much more southern latitudes in North America than in Europe and Asia, thus leaving to man a correspondingly more ample stage for the great drama of physical and cultural evolution than he would have had in the western hemisphere. Whereas the maximum extension of the ice front reached as far south as New York and Cincinnati, which are on about the same parallel of latitude as Naples, the corresponding ice sheet in Europe stopped a little short of London, which is on about the same parallel of latitude as southern Labrador.

Prehistoric Chronology.

During the relatively short historic era, one deals with a chronology which may be called absolute. When it comes to the prehistoric era, one has to be content with approximations—with a relative chronology—as is the case when dealing with the Ice Age or with geologic time. This fact however does not reflect on the validity of prehistoric chronology, or on its scientific value. Where we have to deal with such big units of time, a difference of opinion of even thousands of years is no very serious matter. In consulting various authorities therefore, one should not be surprised to find chronological disparities. For example, we are told by some that the Ice Age began about a million years ago and lasted until some 20,000 years ago. Others would reduce its duration by about one-half. This reduction is generally effected by lopping off the first few hundred thousand years.

But if the prehistorian would dig down to the very roots of the human family tree, he must go farther back in time and deeper into geologic strata than the beginning of the Quaternary or of the Ice Age. The stem from which the human stock sprang may be traced down into the Tertiary. After three months of field work in Europe during the summer of 1903, I



Warren Hill Sand and Gravel Pit in Suffolk, England, Where Thousands of Flint Implements Have Been Found. Paleolithic Period.

returned to America fully convinced that our precursors had lived in the Old World at least as far back as the Pliocene. I made a report to this effect before Section H of the American Association for the Advancement of Science in 1903. At that time there were few who had the hardihood to share this view with me. In the twenty-five years that have elapsed since then,

I have passed from the ranks of the radicals to those of the conservatives without having had to change my views materially.

Man has had then not only a big stage on which to unfold the earliest scenes of the drama of civilization, there has been likewise allotted to him a generous allowance in so far as the time element is concerned. As might be expected, the gradually unfolding records prove that the evolutionary processes, both physical and cultural, have been very slow indeed, especially during the long lapses of time preceeding the appearance of the Cro-Magnon race—*Homo sapiens* properly so-called. The appearance of this race in western Europe is about coincident with the maximum of the Würm epoch of the Ice Age, say some 50,000 years ago.

Technically speaking, this is the beginning of the Upper Paleolithic Period and the Aurignacian Epoch; it marks a phase of unusual significance in the domain of human evolution. Until then man's thoughts as reflected in his kit of tools and the coordination of the brain and hand, which gave rise to his culture, were quite simple. After that time there was a speeding up of cultural evolution with but little difference in the rate of physical change or evolution. The passage from the Middle to the Upper Paleolithic Period was due in a great measure to an increase of facilities for translating individual experience into racial experience. If in all ages the course of progress has been thought out by the gifted few, it is no less true that the rate of progress has always depended on the ability of the many to profit by the achievements of the few; and this ability is conditioned not only by the average plane of mentality but also by the ever-changing nature and complexity of the cultural background.

The American School of Prehistoric Research Uncovering a Dolmen Under Tumulus at St. Saviol (Vienne), France. Late Neolithic and Bronze Age.

Cultural Changes—the Basis of Measuring Time.

Prehistoric chronology is founded on stratigraphy; hence the terminology is not unlike that used by the geologist. It is based primarily on the cultural rather than the skeletal remains of man. The reasons for this are two: (1) cultural remains are more abundant; and (2) cultural changes have taken place more rapidly, are more easily observable, and form a more delicate chronometer. The first tools were obviously ready-to-hand objects such as a stick of wood, a stone, or the bone or horn of an animal. It would be difficult to say which one of these three had precedence over the others in point of time. For obvious reasons it would not seem wise to speak of an age of wood even if there had been one; chief of these is the perishable nature of the material. Even bone is less durable than stone. So that the earlier big divisions of the prehistoric era are based on lithic culture alone and the later divisions are based on cultural remains made of metal. Stone and metal therefore may be looked upon as furnishing the hard parts in the anatomy of the human culture as a body and as corresponding to the bony framework of man and fossil animals, which remains after the soft parts have fallen to decay.

The very beginning of the tool-using stage is called the Eolithic Period, the close of which can best be made to coincide with the close of the Pliocene Epoch of the Tertiary. The second division, or Paleolithic Period, begins with the Pleistocene or Quaternary and is subdivided into the Lower, Middle, and Upper Paleolithic, the last of which is approximately coincident with the last cold epoch of the Ice Age. The Mesolithic and Neolithic Periods, as well as the Age of Metals, belong to Recent Time geologically speaking.

Tumulus of Cros-Guignon Near Civray (Vienne), France. Hallstatt Epoch of the Iron Age (ca. 600 B. C.).

Recent researches by Dubois on the endocranial cast of *Pithecanthropus erectus* show the separation of the frontal and temporal lobes of the brain as in man. There is evidence also that Broca's convolution in the lower frontal region resembles the same region in man more than in the apes. This is the seat of the motor control of speech organs. Another notable feature of the endocranial cast and one that is to be correlated with the development in the region of Broca's convolution is the expansion of the middle temporal convolution, which is the auditory speech center in man. The combination of these two characters in *Pithecanthropus* leaves one to infer a certain familiarity with both motor and auditory phases of articulate speech. Dubois refers *Pithecanthropus* to the Pliocene which translated into the terminology of the prehistorian would mean the Eolithic Period. The first steps in the taming of fire must also have taken place at a very early date, not later than an early phase of the Lower Paleolithic Period.

In a comparative study of industrial remains, there are certain broad distinctions to be drawn. Eolithic industry consisted largely of improvisations—of primary tools such as the hammerstone and the flint with utilizable edge or point. Both are products generously furnished by nature. Where utilizable chips were lacking, man soon learned to produce them artificially, thus supplementing his kit of primary or natural tools by secondary or artificial ones. Secondary tools remained few and simple for a long lapse of time, in fact throughout the Lower Paleolithic Period. The Neanderthal races of the Middle Paleolithic Period made no great advances over their predecessors.

They possessed an improved technique, which is seen in the character of their flint cores or nuclei and well-formed scrapers and points with carefully retouched margins; but so far as has been ascertained, they did not go beyond the making of secondary tools —that is to say their secondary tools served directly an ultimate purpose and were not used for the manufacture of tertiary tools.

It was reserved for the Upper Paleolithic Cro-Magnon races to inaugurate a new era. This was made possible through improvement in the preparation of nuclei, from which long slender blades could be struck. The next step was important additions to their stock of secondary tools (various forms of the graver, microliths, small knives, and awls), which enabled them to make extended use of bone, ivory, and reindeer horn, leading to two capital results—the invention of a set of tertiary tools and the dawn of the fine arts.

Although not an artist in the strict sense of the term, man had reached a point while still in the Neanderthal or Mousterian stage, which gave unmistakable promise of greater things to come. Some of the hand axes and combination scraper-knives of flint he has left to us had already reached the limit of achievement along those lines. He was also a mighty hunter, made use of a simple language, and had taken the initial steps toward taming of fire. There is certainly no reason culturally speaking why we of the twentieth century A. D. should be ashamed to claim kinship with and acknowledge indebtedness to that sturdy pioneer stock.

The Cro-Magnons.

Let us now turn from the really primitive culture which must have been the lot of *Pithecanthropus*, the man of Heidelberg, and of Piltdown, Ehringsdorf, Krapina, and Neanderthal to the new race which appeared above the horizon some 50,000 to 100,000 years ago. Part of England, all of Fennoscandia, Holland, northern Germany, and a large part of Russia were still under the last of the continental ice sheets. Switzerland and most of the Tyrol were also buried beneath the ice. But practically all the rest of Europe was inhabitable; northern Africa and southwestern Asia must have been much more inviting climatically speaking than they are now. The Cro-Magnons obtained possession of the greater part of this territory. Physically they were not unlike the races which succeeded them and those which were living at the dawn of the historic era. They were masters of an improved technique in the preparation of flint cores and had added to their kit of secondary tools those which made it possible not only only to make tertiary tools but also to produce works of art such as figures in the round, in relief, engravings as well as drawings, and frescoes—the latter in both monochrome and polychrome.

The evolution of the fine arts, beginning in the Aurignacian Epoch and ending with the close of the Magdalenian Epoch is one of the outstanding phenomena not only of the Paleolithic Period, but of the entire prehistoric era. Cave art was called forth to meet a need greater than the exuberant demands of the cave man's artistic impulse. It helped to satisfy his love of ornament and sense of the beautiful, yes; but in the hands of a sort of priesthood might it not be made to help in accomplishing that which otherwise would not be possible? It epitomizes man's inborn desire to control unseen and magic forces for his benefit. In his hunter stage of civilization, the multiplication of game animals and success in the chase meant everything; control over animals especially harmful to him also meant much. The four gospels of the caveman may all be read into the art of the period.

Our Contributors

¶ *Robert Keeler Warner, who discusses America's place in mining, received his Ph.B. from Yale in 1911. He was appointed to the faculty at Yale in 1917. During the war he served in the Engineers' Corps, returning to Yale after the Armistice. He became Assistant Professor in 1923.*

¶ *Edward Martin Kindle, who writes on "Canada, North of 56°," holds the degrees of B.A., Indiana University, 1893; M.S., Cornell, 1896; and Ph.D., Yale, 1899. He was a member of the Cornell expedition to Greenland in 1896, and from 1900 to 1910 was connected with the U. S. Geological Survey as paleontologist and geologist. Since 1912 he has been Chief of the Division of Paleontology of the Geological Survey of Canada, and is now a Fellow of the Geological Society of America, American Geological Society, Canadian Mining Institute, and Sigma Xi, as well as the author of numerous papers on geological and allied subjects.*

¶ *Meredith B. Wood, who writes on "Finding One's Place in the World," was a member of the class of 1918 at Yale. He became Captain in the Field Artillery and saw active service from 1917–1919. In 1919 he became associated with the New Jersey Zinc Company. From there he went to the Erickson Company, advertising agents, where he was Assistant Account Executive.*

¶ *Dr. George Grant MacCurdy, who writes on Prehistory, received his B.A. from Harvard in 1893, his M. A. there the following year, and his Ph.D. from Yale in 1905. He is the Director of the American School of Prehistoric Research. Since 1923 he has been Research Associate in Prehistoric Archeology. In 1926 he was sent to the Archeological Congress in Palestine and Syria as delegate from Yale and the Smithsonian Institute. Dr. MacCurdy is a member of the American Philosophical Society and the National Research Council, and the author of "Human Origins, A Manual of Prehistory."*

¶ *Albert Beecher Crawford, who discusses personnel study at Yale, is a Yale graduate of the Class of 1913. As an undergraduate he was an Associate Editor of the "News", Chairman of the 1913 "Yale Banner and Pot Pourri" and although not a member of the board, he was given a "Record" charm for contributions. In his Junior year he made Phi Beta Kappa. When the Department of Personnel Study was founded here last July, he was appointed its first supervisor.*

¶ *Harold Moffet Gould, who writes on traffic problems, graduated from the Sheffield Scientific School in 1907. He served as electrical engineer of the Street Railways of Detroit, and later became Assistant General Manager. For the past two years he has been Consulting Engineer with the Detroit Police Department Traffic Survey. He is a member of the American Society of Electrical Engineers, American Electric Railway Association, American Society of Civil Engineers, Detroit Engineering Society, and the Yale Engineering Association.*

¶ *Clarence M. Young, who writes on commercial aviation, studied law at Drake University and the Yale Law School. During the War he was commissioned First Lieutenant in the aviation but on his first flight over the enemy lines, his plane was disabled by enemy fire and he was held prisoner for five months in Austria. Since the War he has been Executive Secretary of the Bureau of Municipal Research and is at present Director of Aeronautics of the Department of Commerce in Washington.*

Personnel Bureau Aids Undergraduates

Great Increase of Interest in Department of Personnel Study Shows the Advantages of Individualizing Education—Functions of Bureau Explained

A. B. Crawford

THE general purpose of personnel work may be most simply expressed as an attempt to individualize education. Unfortunate "efficiency methods" of personnel organization and operation in some institutions have resulted in quite different interpretations—such as standardization by the use of psychological and other tests, and the apparent application of factory methods to the educational process.

This, however, is a misconception of the true aim of personnel work. Thus President L. B. Hopkins, one of the leading authorities on this topic, has said: ". . . in education, the administration is beset with many serious problems and certain of these problems become so acute at times that there is danger that they may be met and solved without sufficient consideration for their ultimate effect upon the individual student. One of the functions, therefore, of personnel administration is to bring to bear upon any educational problem the point of view which concerns itself primarly with the individual. Thus, in this particular as in all others, personnel work should remain consistent with the theory and purpose of education by tending constantly to emphasize the problem that underlies all other problems of education; namely, how the institution may best serve the individual."

This general purpose has been discussed above as evidence that, after all, personnel work is essentially a common-sense matter and not any kind of an "ism." We believe it should be on an entirely voluntary basis,—that no attempt should be made to force contacts between students and the Department. In certain respects we may be of assistance to individuals, but we realize that there are students who have no desire or need for such service and we shall therefore devote ourselves entirely to those who voluntarily come to us. In fact, a primary aim of the office is that of serving as a central bureau of information for Faculty and undergraduates.

Nature of Service Offered.

Any institution such as Yale presents a certain analogy to the line and staff functions of a military organization. The teachers are the line officers, but offices like the Department of Health, the Bureau of Appointments and the Department of Personnel Study have staff functions, of a somewhat specialized nature, intended to supplement and assist in every way possible the main educational purpose of the institution. For instance, information about individual students, which is now scattered all over the University, can be readily centralized. This need not involve securing anything unusual or any further information than is already on hand about the students, nor does it involve bothering them to get it. It simply means the establishing of an individual cumulative record system that will include significant data now scattered among some six or eight different offices. Thus one simple card will give the essential facts about each student's school, entrance, college and extra-curricular record. This information is obtainable directly from the various offices among which it is at present divided, and therefore need not in any way inconvenience the students. Although of course regarded as confidential, these records will be available to those who have a legitimate purpose for using them. They contain only "impersonal" and objective data chiefly relative to students' academic and extra-curricular activities.

On the other hand, students seeking information regarding the courses of study, business or professional careers, opportunity for graduate work, etc., find that this too is relatively inaccessible and widely scattered. For every Counsellor to acquaint himself fully with all the details of the whole course of study at Yale would be manifestly wasteful, just as it is for students to have to consult many different individuals in order to obtain certain information. While there is no thought that the Department should supplant all such conferences between students and members of the Faculty, it can assume a large part of the informational function and therefore allow greater freedom for consideration, in the highly essential Faculty-Student conferences, of more intricate and important questions.

Responsibility Rests with Student.

It has been assumed by some that the Department of Personnel Study would primarily be a "vocational guidance" bureau. In fact, however, its aim is neither "vocational," in the ordinary connotation; nor "guidance," in the sense of appropriating to itself decisions which should properly remain the responsibility of the individual. It does not favor utilitarian specialization for the undergraduate; it does, on the other hand, believe that orientation with respect to life purpose is a real asset and that the individual who has some purpose in view will probably be a better student in all his subjects than will the one who is wholly disoriented. This does not mean, however, that a student should necessarily pursue courses having an obvious bearing upon his occupational preparation, except in such special cases as are already recognized, e.g., Engineering, Pre-medical requirements, etc.

The Department does not expect to urge specialized training upon undergraduates. It does, however, believe in making available to a student more reliable and more extensive information than is now accessible regarding the different professions and business careers, between which he will ultimately have to choose. If he can be brought to think during college of his subsequent career, he is more likely to appreciate educational and cultural values than if he gives his future occupation no thought until the very end of his undergraduate course. There is thus a great difference between encouraging purpose and fostering specialization. The Department aims, with respect to the choice of course and career, to make information available upon which the student can sensibly base his choice. The responsibility for the decision remains with him, and guidance in the sense of relieving him of this responsibility is not contemplated.

Experiments may be undertaken with regard to the analysis of interests and aptitudes, if by these means further information

may be placed at the disposal of the individual. All such work, however, is still wholly in the experimental stage and no reliance can be placed today upon its methods. Our procedure will, therefore, be that of personal conferences with the student, and the attempt will be made to place at his disposal information which he seeks, without any effort to decide what he must do. In the present state of occupational technique, attempts at omniscient guidance would be indefensible.

Functions of Department of Personnel Study.

The main functions, therefore, of the Department of Personnel Study insofar as they have been considered, are:

(1) Orientation, carried on largely through the existing Freshman Counsellor System, in an attempt to help the individual student find what he wants at Yale. This involves analysis of the course of study so that information regarding the content and aim of various courses may be more readily obtained by the student. Conferences with the various departments of the University are planned with this view. This function is one which a Counsellor would undertake, if he had the time to devote to a thorough-going analysis of the educational opportunities in the various departments. The Department hopes in a sense to perform this function for the Counsellor and to make such information available to him and to the student. The office facilities and data of the Department will always be available to Counsellors for this purpose.

(2) Occupational Data. It is planned to collect more reliable and comparable information regarding the professional and business careers in which students are interested, and to have a small reference library available for them to consult. It is also planned to prepare, from the point of view of the college student, a series of monographs on professional and business occupations. These should be uniform in methods and presentation and based upon more reliable and complete data than any now available.

(3) Placement. Heretofore, the Bureau of Appointments' service has been necessarily limited to business positions. The new Department contemplates also assisting students wishing to secure further training for the professions or certain business careers in which graduate training may be of particular value. It is hoped, through the following up of placements made, to secure, by analysis of the progress of individual cases, subsequent information of value to the Department and future students.

(4) Records. A centralized, cumulative record system has been inaugurated which will conveniently gather information about students now scattered in various offices. The individual's record card, which contains the essential items of the individual's school and entrance record, will, as he progresses, also include data about his class room and extra-curricular activities. This will be of great importance to the Department in its conferences with the student and will undoubtedly prove a convenience to the other offices and departments of the University.

(5) Personnel Research. The department will attempt, so far as its facilities permit, to undertake research on such special problems as may be referred to us by other departments of the University. Three such problems have already been undertaken. Research work in the general Personnel field as well as specific problems referred to us by different departments may become important activities of the Department.

Growth in Senior Registration.

The growth in registration and placement of graduating seniors by the Bureau of Appointments during the last five years clearly indicates the development of students' interest in such facilities. Applications filed from seniors seeking business opportunities after graduation rose steadily from only 93 in 1923 to 223 last year, and placements more than doubled during that period. Between 50 and 60 per cent of the senior registrants are usually placed directly by this service. Incorporation of the Personnel Office and the Bureau of Appointments into one department under the same general direction is in fact intended to facilitate extension of this work with Seniors.

Two important short-comings we have felt during the past few years of this development have been, *first;* lack of adequate and reliable information concerning business and professional careers and our consequent inability to answer students' questions about this or that company, profession, or type of business, and *second;* postponement of conferences with students concerning their choice of an occupation until very nearly the close of their undergraduate course. While the Personnel Department has in its first year made only the slightest beginning toward improvement in certain of these respects, it does hope eventually to make progress. So much needs to be done, however, particularly in respect to the study of occupations and their possible relation to student work in college, that it would be folly for us to expect to advance rapidly along these lines.

Of the present Senior classes in the College and Sheff, more than 300, or nearly half of the total number of students, are at present in contact with the office. Of these, 236 have registered for business positions and about 30 more for teaching appointments. Over 50 have consulted us with reference to professional study of one form or another—Law, Medicine, Business Administration, Architecture, etc. During the months of March and April, many firms have visited us to talk with seniors regarding positions which they had to offer and several hundred interviews have been arranged with them and the Senior registrants. Nearly one hundred more firms who have not sent interviewers to New Haven have written us about openings for graduating Seniors.

Correspondence with these firms about registrants and the arranging of interviews day after day, which involves first the selection of possible candidates for positions and next the scheduling of definite appointments with firms, (to say nothing of our own initial and follow-up conferences with the Seniors) entail altogether a considerable amount of work to be crowded into such a relatively short period as three months. That is one reason why we should like to cultivate among students the habit of beginning earlier than the second term of the Senior year to consider what their next step will be.

The Department has on its Governing Board the Provost, Secretary and Comptroller of the University, the Undergraduate Deans, the Dean of the Graduate School, the Chairman of the Board of Admissions, and representatives of the three Undergraduate Student Councils. Its guiding principle in general will be the needs and desires of the student body and advice of the Faculty, with reference to the problems of the individual in relation to selecting his course of study and subsequent career.

As time goes on, certain parts of this plan may appear impracticable and other possibilities not yet contemplated may be suggested. In fact the Department is committed to no predetermined program except that of trying to make itself useful. What it most desires now is advice and assistance in developing from these functions tenatively undertaken, a definite outline of procedure.

America Leads World in Mining Industries

Supplies Virtually Half of World Production except in Tin, Manganese, Nickel and Precious Metals. All Other Industries Rely on Mining for Existence

Prof. Robert K. Warner

THE mining industry supplies the raw materials on which all other industry, even agriculture, exists. To realize the importance of mining and the allied industries one needs but to consider what would become of our industrial civilization if the production of fuels, metals, and other mineral products should cease or decline. From the bronze age on the possession and use of metals and laterly of mineral fuels have allowed races and nations to gain power often at the expense of those of their competitors who were either less well endowed with natural resources or less active in exploiting those that they had. With the growth of machines, which today are made of alloys of metals, driven by mineral fuels and lubricated by mineral oils, the demand on the miner was in some instances doubled every decade. It might be expected that such an increased consumption would result in a correspondingly increased price but a glance at the attached table will show that this is not the case. In spite of the fact that the richest deposits in any country are usually those which are first exhausted and that our metals are now coming from leaner ores than at any time in the past, the price of metals has not risen at a more rapid rate than other articles of commerce.

The table below contains statistics as to the relative production and price of fifteen of the more important mineral products. The figures have been simplified by making the 1907 world production and cost 100 in each case and adjusting the other figures to this basis. The things that stand out in this table are (1) the United States and the adjacent geographical units produce much more of the world's minerals per capita than any other part of the world and in many cases more than the rest of the world put together. Excepting the precious metals, gold and platinum; the alloying metals for steel making, chromium, manganese, and

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Year	Production: United States	Production: North America	Production: Western Hemisphere	Production: World	Price
	ALUMINUM				
Latest	210	263	263	600	60
1917	169	205	205	370	115
1907	36	50	50	100	100
1897	6	6	6	10	87
	CHROMIUM ORE				
Latest	0.1	12	12	231	105
1917	46	81	83	243	134
1907	0.4	7	7	100	100
1897	0.2	6	6	46	138
	COAL				
Latest	61	62	62	137	186
1917	73	74	74	165	273
1907	44	45	45	100	100
1897	18	19	19	64	68
	COPPER				
Latest	109	127	161	203	69
1917	120	134	154	198	136
1907	56	64	74	100	100
1897	31	34	37	57	56
	GOLD				
Latest	11	24	27	97	100
1917	20	28	32	103	100
1907	22	29	32	103	100
1897	14	18	21	58	100

Year	Production: United States	Production: North America	Production: Western Hemisphere	Production: World	Price
	PIG IRON				
Latest	65	66	66	128	94
1917	65	66	66	119	193
1907	43	44	44	100	100
1897	16	16	16	55	46
	LEAD				
Latest	62	95	97	158	158
1917	52	58	58	112	165
1907	32	39	39	100	100
1897	18	27	27	71	67
	MANGANESE ORE				
Latest	3	4	14	89	155
1917	4	7	25	65	505
1907	22	23	31	100	100
1897	6	6	7	31	146
	NICKEL				
Latest	1.5	208	208	227	83
1917	2	237	237	272	125
1907	0	59	59	100	100
1897	0.1	11	11	22	72
	PETROLEUM				
Latest	290	324	349	411	202
1917	127	148	150	190	187
1907	63	64	64	100	100
1897	23	23	23	46	45

Year	Production: United States	Production: North America	Production: Western Hemisphere	Production: World	Price
	PLATINUM				
Latest	1	5	20	44	366
1917	2	2	11	24	332
1907	0.1	0.1	3	100	100
1897	0	0	0	124	49
	SILVER				
Latest	33	101	118	137	96
1917	39	75	81	102	125
1907	31	72	74	100	100
1897	31	64	75	99	92
	SULPHUR				
Latest	235	235	235	276	500
1917	142	142	144	196	579
1907	39	39	39	100	100
1897	0.2	0.2	0.3	66	84
	TIN				
Latest	0	0	32	141	167
1917	0.1	0.1	27	128	162
1907	0	0	19	100	100
1897	0	0	6	74	36
	ZINC				
Latest	75	83	83	165	126
1917	84	85	85	136	150
1907	31	31	31	100	100
1897	12	12	12	59	68

Commercial Aviation in the United States

Great Progress in Aviation Shown by Present Day Planes, Airways, Regulations —Functions of Aeronautics Branch of Department of Commerce Explained

Clarence M. Young

COMMERCIAL aviation is a thing of the immediate present. It must be reckoned with by every community and every industry. It has become a part of the general transportation scheme of the country and will soon be as indispensable to industrial and social progress as is any other method of transportation. We are at times rather prone to think of it as something for a future generation to worry about—something that is in evidence at the moment but more or less a curiosity, a pasttime for the adventurous, or a military necessity in time of war. We sometimes see an old wartime training plane operating from a small field near a community, carrying passengers on short "hops" for a dollar or so the ride, and perhaps think it representative of present day activities. Such is not the case. It is merely the tag end, the tenacious pioneer, of an industry—a transportation business that is employing thousands of men, with millions of capital invested, and operating both day and night on schedules as precise and accurate as those of any railroad.

Present-day flying may be divided into three classes: (1) air transport, (2) commercial air service, and (3) private.

Air transport flying includes scheduled operations over established routes with mail, passengers, and express. These routes now cover 10,792 miles over which airplanes fly 22,865 miles daily. Definite daily schedules are followed with a precision equal to that of the best railroads. These scheduled air lines serve cities and directly connected trading areas totaling 66,-000,000 population.

Air mail is flown over 10,000 miles of the routes, but in addition there are five companies operating six routes carrying passengers or express or both, which are not dependent upon air mail for their income. Part of the companies carrying mail also carry passengers and express, while four offer one of these two services. Almost all of the others are considering definite and comprehensive plans for all three classes of operations.

On some of the larger routes three-engine cabin planes will be used and already this type of plane is operated on a few of the shorter routes.

However, this scheduled air transport service is only one-tenth of all the flying in the United States. With the exception of private flights most of this remaining amount is made up of commercial air service. This includes taxi service, aerial photography, surveying, mapping, sight-seeing, messenger service, crop dusting, and many other industrial services. The commercial operator is the pioneer of commercial aviation. He is the one who has kept flight before the public during development years following the World War. Accurate records for 1927 are not yet completed, but it is certain that they will far surpass the remarkable figure of 1926—more than 19,000,000 miles.

The development of private flying for both business and pleasure purposes has been most unexpected. Corporations and individual business men are purchasing the most modern types of aircraft for business purposes. They are making profitable use of them in sales work, business travel and special delivery service. Comfortable cabin-type planes of suitable capacity are available at moderate initial and operating cost; a competent pilot can be qualified for other duties, and enough time saved the busy executive more than to offset any additional cost involved. The time is imminent when the American business man will make a comprehensive use of his privately operated airplane and, once adopted, it will become as indispensable to his business as his automobile.

Improvements in the Modern Plane.

The airplane of today is not that of a few years ago. It is stable, safe, reliable, and much more comfortable. One may step into a cabin type plane, take a comfortable seat, and deport himself in much the same manner as in a closed automobile of the most modern construction. The leather coat, helmet, and other special paraphernalia are quite as obsolete as the goggles, gauntlet gloves and linen duster of the early automobile days. There has been developed an air sedan which cruises at 100 miles an hour or more, and which is equipped to give the greatest possible comfort and reliability.

The equipment of these planes often includes individual wheel brakes, starters, heaters, electric light systems, comfortable and even luxurious upholstery, separate baggage compartments, wide vision windows and attractive fittings. Cabins are being constructed so as to be as nearly sound proof as possible. Landing gear has been improved so that the action of alighting creates no undesirable sensation.

The wood and wire construction of wartime days has become practically obsolete, being superseded by welded steel tubing and other metal construction so far as the fuselage is concerned. Wing construction is divided between wood and wire with fabric covering, and metal.

Air-cooled engines have come into greater use in commercial aviation although there are still a number of planes which are especially designed for the 90 h.p. water-cooled engine.

In all phases of aircraft and engine manufacture the demand far exceeds the supply. Figures for 1927 show that there were over 2,000 commercial planes alone produced, and that almost all of the larger factories had numerous unfilled orders at the close of the year. There will undoubtedly be an increase of 75 per cent in the production of commercial airplanes for 1928. This is a conservative estimate.

Great Development in Airport Facilities.

Airport development throughout the entire United States has been remarkable. Enterprising communities everywhere have realized that it is as impossible to have aviation activities without airport facilities as it is to have railroad and automobile service without terminals and highways, and have intelligently gone about the establishment of them.

The Department now has a record of 523 permanently established airports, both municipal and private. The unit investment in them varies from forty or fifty thousand dollars up to a million and more, depending upon size, location, etc. There are also 154 Department of Commerce fields along established airways, 79 other government fields of the Army, Navy, and

other departments, and over 320 fields of miscellaneous classification that are both available and usable. This is but an indication of the future. Literally hundreds of communities have called upon the Department for advice and assistance in the selection and establishment of airports and landing fields. These do not represent inquiries of mere curiosity and casual interest. Each has a specific objective in mind and are making definite moves in the premises. The Department is cooperating with 422 municipalities which have proposed construction of airports or are actually engaged in such construction.

In addition to these airports there are approximately 4,000 emergency fields throughout the United States on which landings can be made if necessary.

Functions of Aeronautics Branch of Department of Commerce.

Prior to the passage of the Air Commerce Act of 1926 there was a great deal of confusion in the aviation industry, particularly on account of the lack of regulation and definite aim which existed. The Air Commerce Act charged the Secretary of Commerce with the regulation of civil aeronautics. It created the office of Assistant Secretary for Aeronautics and established the Aeronautics Branch of the Department.

The one and only purpose back of it is the promotion of commercial aviation—the development of its usefulness to the fullest possible extent in the United States where aviation found its inception.

This can best be done by the promotion of public confidence in it—a confidence that will take it for granted in the same manner it does the automobile, the railroad, and the steamship—and this can be accomplished only by bringing about the combination of four essentials:

1. Airworthy aircraft, efficiently maintained,
2. Competent pilots,
3. Suitable equipped airways, and
4. Standard air traffic rules.

It is this that constitutes the objective of the Department, and is the premise of the Air Commerce Regulations which were drafted and made effective following the passage of the Act.

The organization with which to carry on the work is made up of four main divisions as follows:

1. Air Regulations,
2. Airways,
3. Information,
4. Experimental.

In addition provision has been made for cooperation between the Weather Bureau and the Coast and Geodetic Survey for suitable weather service and airway map preparation.

Referring to them in the order named, the Air Regulations Division presents itself for consideration first. It is charged with the duty of inspecting and examining aircraft and pilots and mechanics for licenses, the identification of all aircraft not licensed, the enforcement of air traffic rules, and the investigation of accidents. Some idea of the volume and extent of the work at the present time can be gained from the fact that to date they have received 14,594 applications for aircraft and airmen's licenses and for identification markings, to say nothing of the other phases involved.

The Airways Division is at present a part of the Bureau of Lighthouses, one of the old and established bureaus of the Department. Its function is the establishment, equipment and maintenance of airways. The equipment includes such aids to air navigation as intermediate fields with boundary markers, etc., beacon lights, radio service, and, in cooperation with the Weather Bureau, a suitable weather service. At the present time, there are 10,792 miles of established airways over which scheduled service is being maintained; 5,804 miles of these airways are lighted for continuous night operations, and 1,764 miles in addition will be equipped with lighting facilities by June 30, 1928. There are aerial highways open to every aircraft operator and constitute a government aid of untold value to commercial aviation.

The functions of the Air Information Division include the collection and dissemination of all sorts of information concerning the operation of commercial aviation both in the United States and abroad; the preparation of landing field bulletins, the distribution of Air Commerce Regulations, of Airways Maps, the collection of statistical information for insurance and trade promotion purposes, and the development of such other informative material as will make readily available complete pertinent information of all aviation activities.

The Air Commerce Act provided for experimental work in the development of additional aids to air navigation. This is being done at the Bureau of Standards, also an established bureau of the Department. Present work includes the perfection of the radio beacon and other radio aids, the testing of aircraft engines, propellers, instruments and other aircraft appurtenances. The radio beacon is receiving major attention at the present time. It is a device designed to be of particular aid to pilots operating at night or in unfavorable weather conditions.

State Cooperation in Regulation Needed.

The Department of Commerce has control only over interstate flying so far as licensing is concerned although its air traffic rules apply to all commercial and civil operations. The Department requires that all airplanes carry identification numbers whether engaged in interstate, intrastate, or private operations, but it can not establish minimum requirements for structural standards in airplanes which are operated solely within one State. As a result airplanes which might be and frequently are condemned by the Department's inspectors and are refused Federal licenses for interstate commerce may obtain identification numbers and operate within their own State carrying passengers or property.

The only effective method of covering this situation is by State legislative action. This has already been initiated in several States and is being considered in others. The result of such legislative action in all of the States will eliminate the condemned or unairworthy airplane. The result will be that the confidence of the laymen will be greatly increased. At present it makes no difference to him whether he reads that an airplane which crashed was identified or licensed. He does not understand that the licensed airplane would have been inspected and passed as airworthy, while the identified airplane may have been one that was condemned by the Department of Commerce.

Licensing of all aircraft creates a feeling of responsibility in the pilot who may lose his license or have some penalty inflicted if he fails to comply with the Air Commerce Regulations either in operation of his plane or in maintaining it in proper condition.

Mechanical Failures, the Human Element, Weather.

In the matter of accidents themselves there will be a constant reduction in the percentage even though the number will naturally increase with the amount of airplanes put into operation. The causes of airplane acidents may be classified as follows: (1) mechanical, (2) the human element, and (3) weather.

The Department of Commerce requirements for airworthiness as a prerequisite to licensing have made it improbable that future

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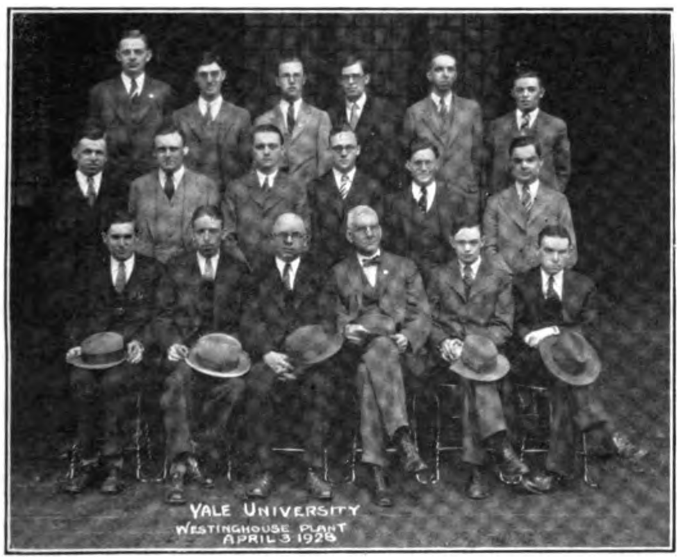
Engineering Students Make Inspection Trip

Seniors in the Industrial, Mechanical, and Electrical Engineering Courses Take Annual Spring Trip to Visit Factories and Power Plants in the East

UNDER the direction of Professor H. L. Seward, 1906 S., seventy-seven seniors in the Industrial and Mechanical Engineering Courses spent the week immediately preceding Easter Recess in making the annual inspection trip. The group assembled in New York City on Wednesday, March twenty-eighth, and was disbanded after the Yale Alumni dinner in Dayton, Ohio, on April fourth. At the same time Professor C. F. Scott conducted a party consisting of fourteen seniors in Electrical Engineering along a different itinerary which, however, coincided with that of the larger group for one day in New York and one day in Pittsburgh.

The Mechanical-Industrial group first visited the American Telephone and Têlegraph Building on Broadway, where they were addressed by the Vice-President, Mr. Gherardi. After having lunch as the guests of the Company, they took busses

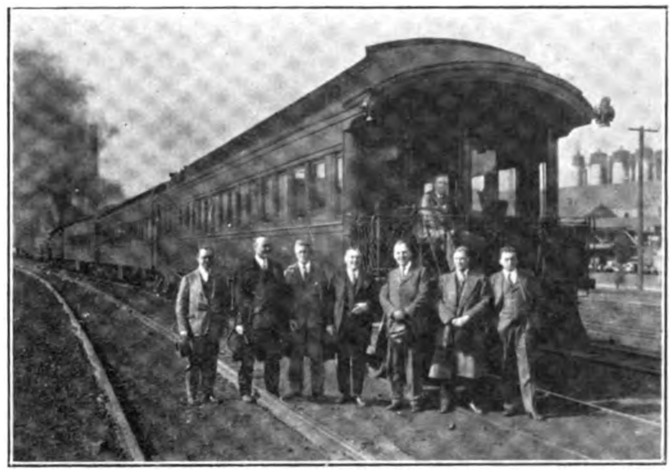


Seniors in Electrical Engineering who took the Inspection Trip under guidance of Professors C. F. Scott and A. E. Knowlton. Picture taken at the Westinghouse Plant in East Pittsburgh.

through the Holland Tunnel to the Kearny, N. J., works of the Western Electric Company, a subsidiary of the Bell System. Two days followed in Philadelphia, where the Victor Talking Machine Company, Sears-Roebuck, Keystone Aircraft Corporation, and the Naval Aircraft Buildings of the Philadelphia Navy Yard were visited in order. The Mechanical Engineers were in Philadelphia for the third day of the trip only, having stayed in New York for the purpose of seeing the New York Edison Company and the Sperry Gyroscope Company.

The fourth day was spent in Altoona, where the vast shops of the Pennsylvania Railroad and the freight classification yards were viewed before proceeding to Pittsburgh late in the afternoon. With Pittsburgh as headquarters, a day's trip was made to the mills of the Carnegie Steel Company at Homestead, the Carnegie furnaces at South Duquesne, and the Coke and By-Products Works at Clairton. The entire following day was spent in the Goodrich Rubber Company's plant in Akron, after which an overnight run was made to Dayton to see the National Cash Register Company and the Fairfield Flying Field, the last two features of the trip.

In the meantime, after the first day spent with the larger group, Profesor Scott's party went from New York to Schenectady, where the General Electric Works were inspected. From Schenectady the party proceeded to Niagara Falls for a two-day visit which included the main plant and two stations of the Niagara Falls Power Company, the Kimberly Clark Paper Company, the Carborundum Company, the Shredded Wheat Power Company, and two plants and a transformer station of the Hydro-Electric Power Commission. Next the group joined the Industrial-Mechanical party to go through the Homestead, South Duquesne, and Clairton Works of the Carnegie Steel Company



Officials of the Pennsylvania Railroad who were assigned to the Inspection Trip with some of the faculty members shown with the special train used from Altoona to Dayton.

Seniors in Industrial and Mechanical Engineering with Professors Seward, Dudley, and Hastings, and Mr. Q. E. Seeley at the National Cash Register Co. in Dayton, Ohio.

(Continued on page 46)

Studying the Street Traffic Problem

The Detroit Police Department Makes a Survey of Street Traffic for the Purpose of Alleviating the Present Congestion

H. M. GOULD

DETROIT, in common with most cities, is faced with the problem of handling its street, alley and sidewalk traffic more efficiently and expeditiously. To solve this problem quickly, economically and to the satisfaction of all the interests concerned is a task of great magnitude because of the many factors involved and because of the diverse opinions as to what constitutes an equitable solution. The problem has come to us through evolutionary changes, which have placed a cumulative burden on our streets. The solution of the problem will likewise be by evolutionary remedial changes rather than by any immediate spectacular measures.

The recognition of the need for reducing traffic hazards and the economic losses due to traffic congestion, and the possibilities of making more efficient use of our highways prompted the Detroit Traffic Survey.

The automobile, the bus, and the trolley car have definite places in the transportation field; and there is only required a complete recognition of that fact, with a determination to see that those places are properly filled, materially to improve traffic movement.

Those who utilize the three types of vehicles just mentioned have certain rights, but the rights of one class must not take precedence over the rights of the others. The thought has been expressed that restrictions on the use of the automobile must not be entertained because of a fancied injury to the automotive industry. In reality, more harm can be done the producers of automobiles by allowing the operators of such equipment a free rein and then suddenly imposing drastic regulations than if reasonable regulations were applied in the first place.

It is believed that a strict compliance with the traffic ordinance for parking in the business district would not act as a deterrent to motorists driving into the congested areas; but would simply have the effect of changing the storage habits of those who now store their automobiles in the street, thereby releasing considerable curb parking space for shopping and short time business transactions.

Parking and Storage Space.

It does not seem consistent to spend money to widen streets just to provide parking and storage space for vehicles and then wonder why taxes and assessments are burdensome. If there is a legitimate demand for "movement" space that cannot be met by existing facilities, then expenditures for street widening must be made. But first of all, it should be determined that the demand exists and can be satisfied in no other way.

All increase in the amount of "off street" parking with a reduction in street parking will be of material assistance in traffic movement, especially on thoroughfares used by trolley cars and buses, and on narrow thoroughfares that would act as by-pass routes were it not for the presence of parked vehicles.

Operators of parking lots and "For Hire" garages could very properly consider increasing their returns and assist in a reduction of street parking by basing their charges on the length of time vehicles utilize those facilities, rather than on a flat rate basis. Certain garages do have sliding scale rates in effect, but the practice is not general. Doubtless many motorists desiring parking spaces for short periods would be more inclined to patronize parking lots or garages if they were not required to pay the full-time rates.

Night street storage of vehicles, notwithstanding a deficiency of garage facilities in some sections of the city, can be eliminated if undertaken gradually, viz., the serving of notice through an ordinance that one year thereafter such storage will be prohibited, with an effort meanwhile to help the situation by a more liberal use of apartment house property for garaging purposes (if this can be done without sacrificing safety), and a prohibition of vehicle parking on one side of every street where the pavement width is less than thirty-six feet. The last mentioned prohibition would aid the fire department in its work, expedite the movement of vehicles through narrow streets and reduce the number of accidents, both vehicular and pedestrian. The paving and lighting of alleys in residence districts would be a contributing factor in the reduction of night street storage of motor vehicles. The presence of unguarded vehicles in the street during the night is a temptation for unprincipled persons to appropriate them or accessories from them, and this is probably a contributory factor in the recent rise in automobile theft insurance rates in Detroit. The theft of automobiles has another exceptionally disagreeable feature since it is in stolen automobiles that the great majority of bank robberies, store and residence hold-ups, and other crimes are made.

Facilitating "Fluid" Traffic.

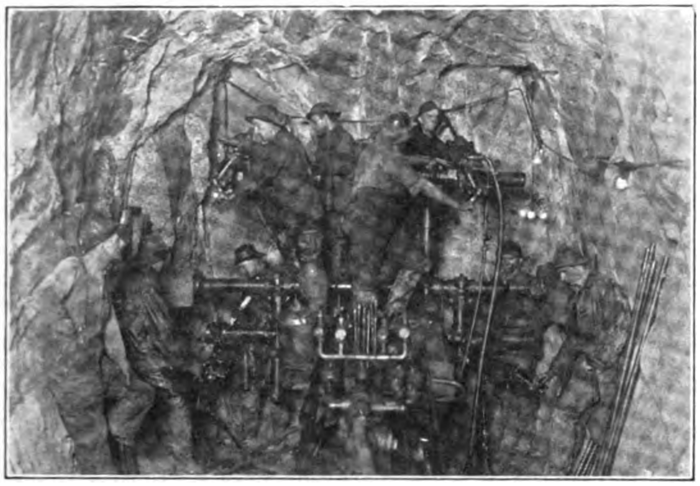
Closely allied with vehicular movements and parking in the downtown business district is the matter of rapid vehicular movement between that district and any other districts, business or residential.

To aid and abet the flow of traffic into the downtown business district in the morning and out of the downtown business district in the afternoon is of the utmost importance, not only to the interests within this district, but also to the city as a whole. In other words, the vehicular speed of street car, bus, private automobile, truck and horsedrawn vehicle should be such as to use most effectively the "travel lanes" now available.

The desired efficient use and "economical" speed can be procured by putting into practice the following: (a) group movement of vehicles by use of platoon type automatic traffic signals; (b) the keeping open in each street of as many "travel lanes" as is practicable, more especially during the morning and evening rush hours; and, (c) a reduction in the number of stops made by all vehicles, particularly street cars and those having slow speed characteristics.

The platoon type of signal has already been installed on one main thoroughfare in Detroit and another main thoroughfare will be so equipped within a short time. This type of signal is designed to permit vehicular movements in fleets or platoons provided the vehicles travel at the advertised rate of speed. Incorporated in this installation is the so-called "split" amber principle in which the amber light is used only to warn moving

(Continued on page 32)



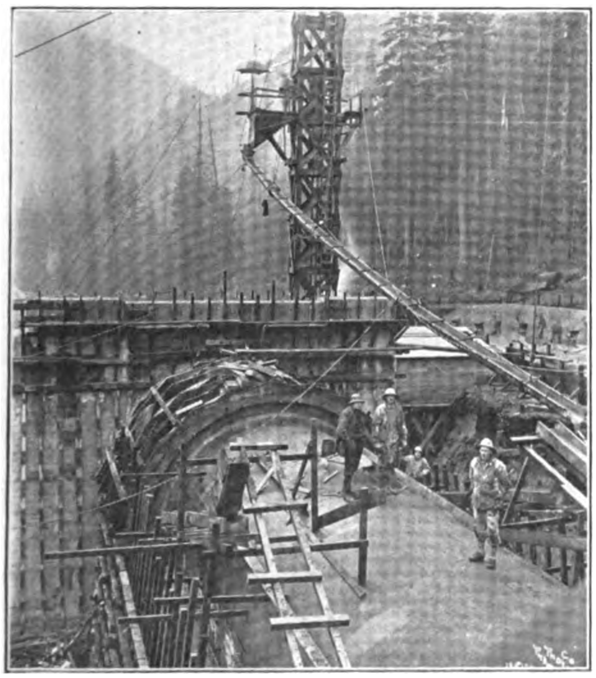
ABOVE.—*Drilling on one of the crosscuts.*

ABOVE.—*Water encountered in the Pioneer Tunnel.*

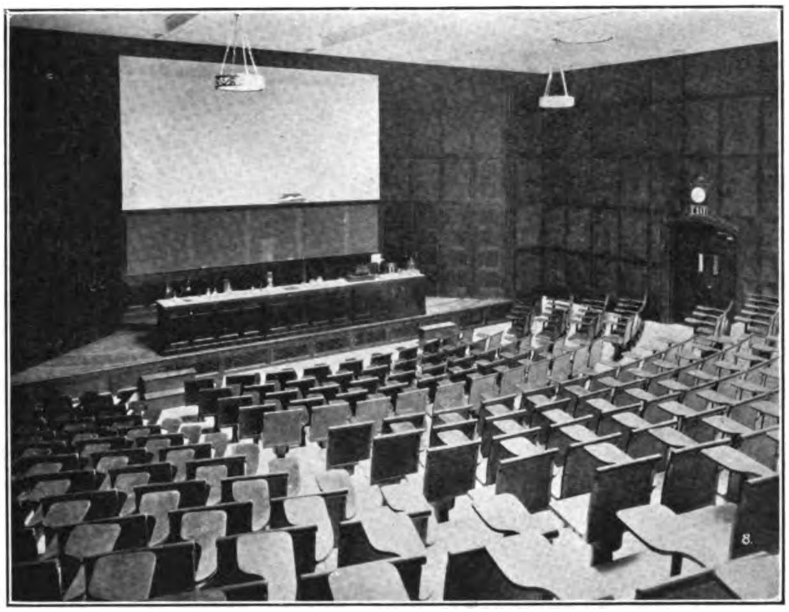
The New Cascade Tunnel of the Great Northern Ry. is located about 90 miles east of Seattle, cutting the summit of the Cascade Mts. It is to be 7.78 miles long, the longest railroad tunnel on this continent, electrified, and concrete lined throughout, with a grade of 1.565%. It will reduce the mileage by 7.68 miles and the curvature by 1950°. It is being built from both ends and from a shaft sunk in the middle, with a pioneer drift 66 feet south of the main tunnel extending from the West Portal to the shaft, cross-cuts being made to the tunnel every 1500 feet. In the main tunnel, a center heading was pushed through, followed by enlargement by ring drilling. On May first, the east and west ends of the Pioneer Tunnel met, and trains will probably be running by the first of December. A. Guthrie and Co. have the contract. Scenes about the work are shown on this page.

ABOVE.—*The West Portal. The center line of the tunnel passes approximately through the peak.*

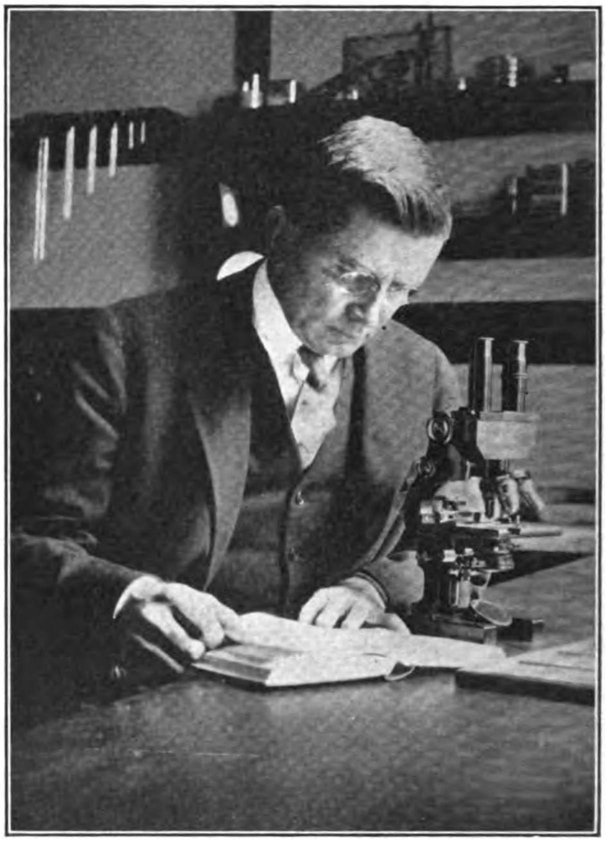
BELOW.—*Pouring concrete on the West Portal.*



ABOVE.—*The crew that broke through between the East Portal and Mill Creek Shaft.*



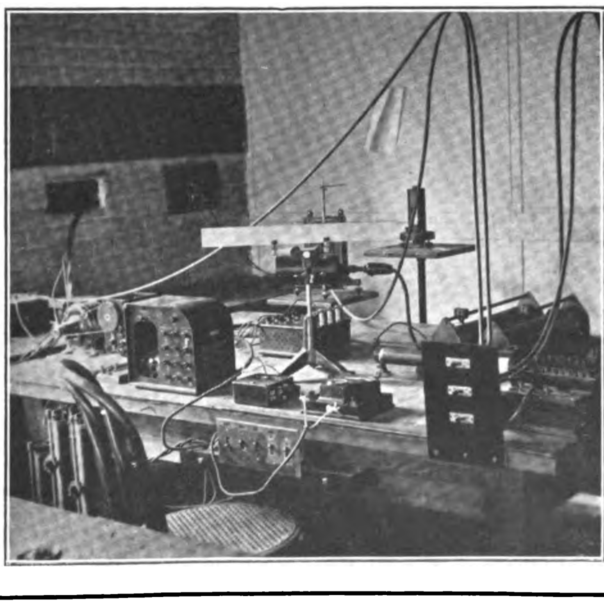
Above.—*Lecture room in the Sterling Chemistry Laboratory, showing table and apparatus. Excellent acoustics have been obtained by use of pressed cork for the walls.*



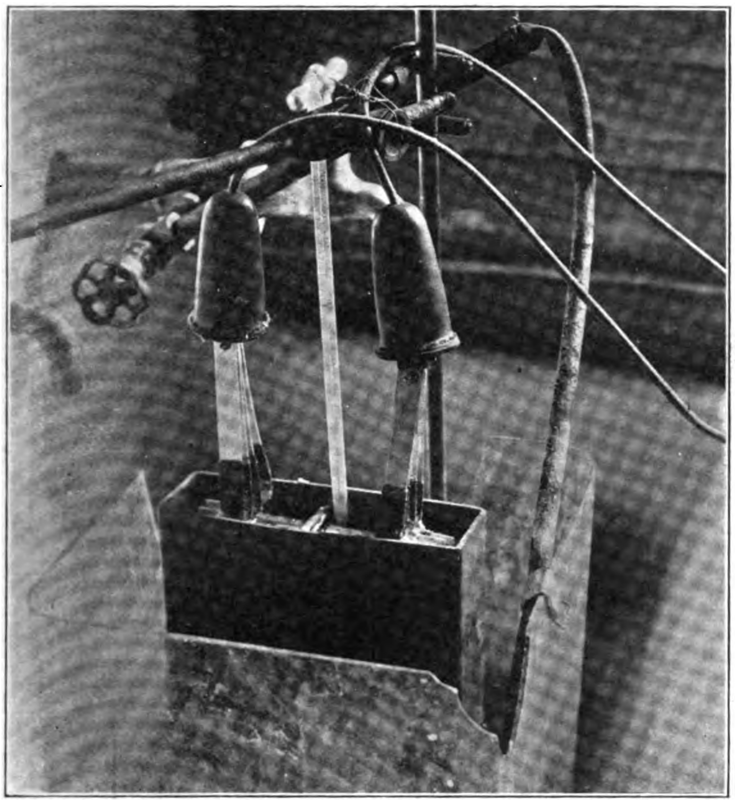
Above.—*Professor G. A. Baitsell, recently promoted to be Professor of Biology. He received the degrees of M.A. and Ph.D. at Yale in 1909 and 1914, and since then has been a member of the Yale faculty.*

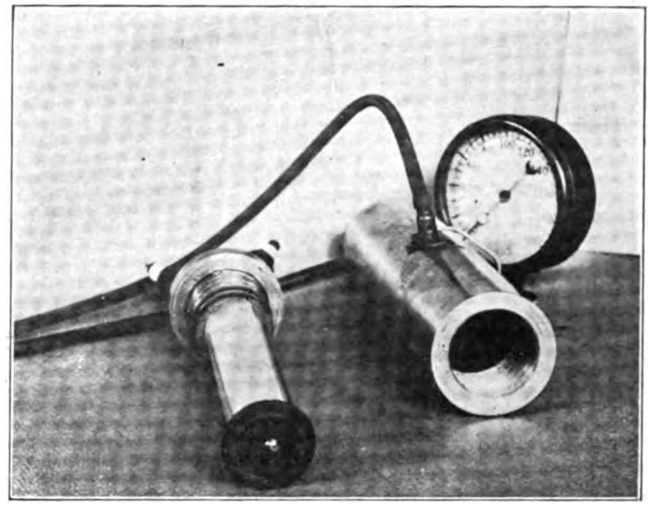
Left.—*Dr. A. W. Hull (1905, Ph.D. 1909), who is with the Research Laboratories of the General Electric Company, recently delivered two of the DeForest Lectures on the development of the new types of vacuum tubes.*

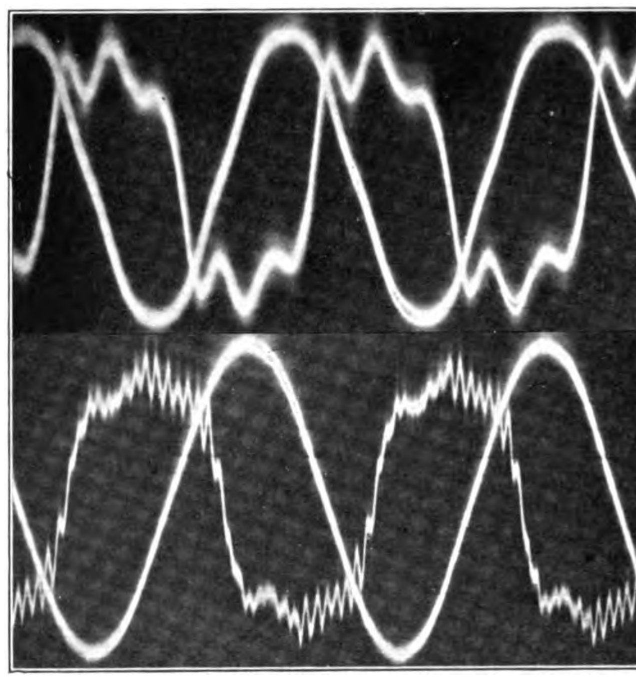
Above.—*Mr. A. J. Ralph, Technician, to whose skill is due many of the refinements in the Dunham Laboratory. At the left of the precision lathe is the belt drive for normal speeds and also a shaft drive with a worm reduction for very low speeds.*



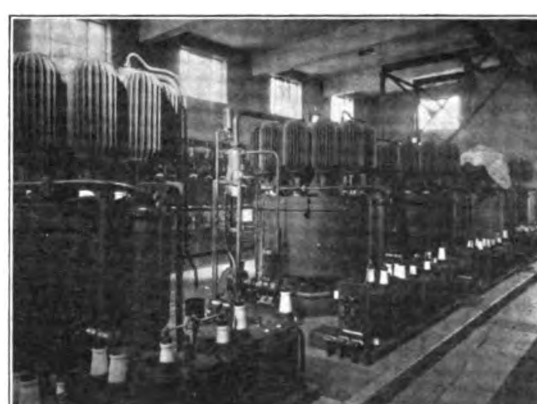
Left.—*Apparatus for control and study of the Fahy Permeameter. This is an instrument invented by Frank P. Fahy, '02 S., for the measurement of magnetic properties of iron, and presented by him to the Department of Electrical Engineering for critical study and analysis.*







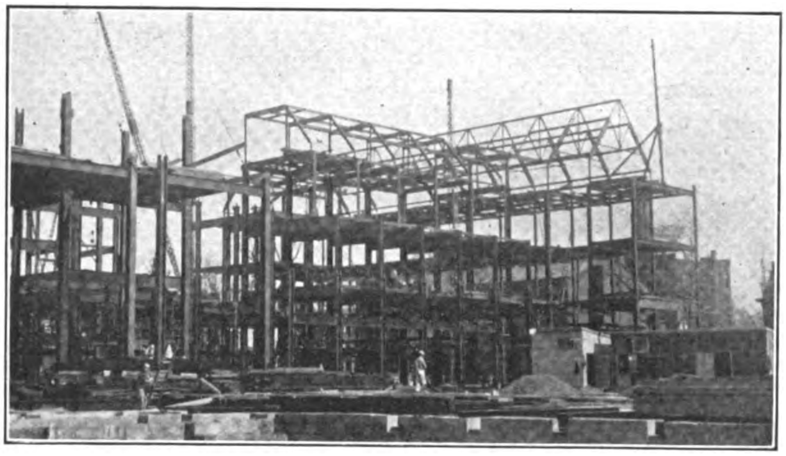
An investigation into the performance of electrolytic condensers is being made by the Electrical Engineering Department under the supervision of Professor W. B. Hall, '16 S. They provide several times as much capacity as ordinary condensers in the same space, and have other distinctive valuable properties, together with some objectionable features. The above picture shows a cell made of aluminum plates in a solution and set in a glass jar of water so that the cell temperature may be controlled. The pictures at the right are oscillograms of the voltage and current of the condenser. The smooth wave is the 60 cycle alternating voltage. The wave with the ripple is the condenser current. These waves show a variation in capacity during the cycle. The dielectric in these condensers seems to be a gas layer which forms on the plates. This layer is under heavy solution pressure. The upper right picture shows a similar condenser constructed so that high pressures may be applied, from which the pressure characteristics of this layer are being studied.



LEFT AND ABOVE.—*Battery of five mercury arc rectifiers at the Bridgeport sub-station of the Connecticut Co., supplying 600 volts D. C. to trolley mains from 550 volts double-six phase A.C. Rectification is accomplished by mercury vapor arcs acting within a water-cooled chamber at a pressure within .001 to .005 centimeters of a perfect vacuum.*

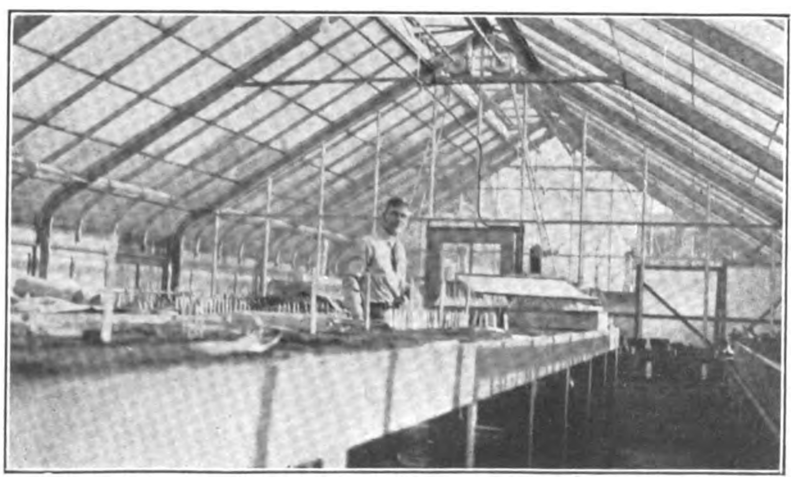
Above.—*Transplanting forest trees in the field. A class of students in forestry.*

Left.—*Professor W. J. Wohlenberg has been promoted to be Professor of Mechanical Engineering. He graduated from the University of Nebraska in 1910, and received his M.S. degree from the University of Illinois in 1916.*



Left.—*A view showing the progress of construction on the Sterling Memorial Library. The contractors hope to complete the Library in two years.*

Below.—*Professor H. L. Seward, recently promoted to be Professor of Mechanical Engineering. He received his Ph.B. degree from Yale in 1906, and his M.E. degree in 1908.*

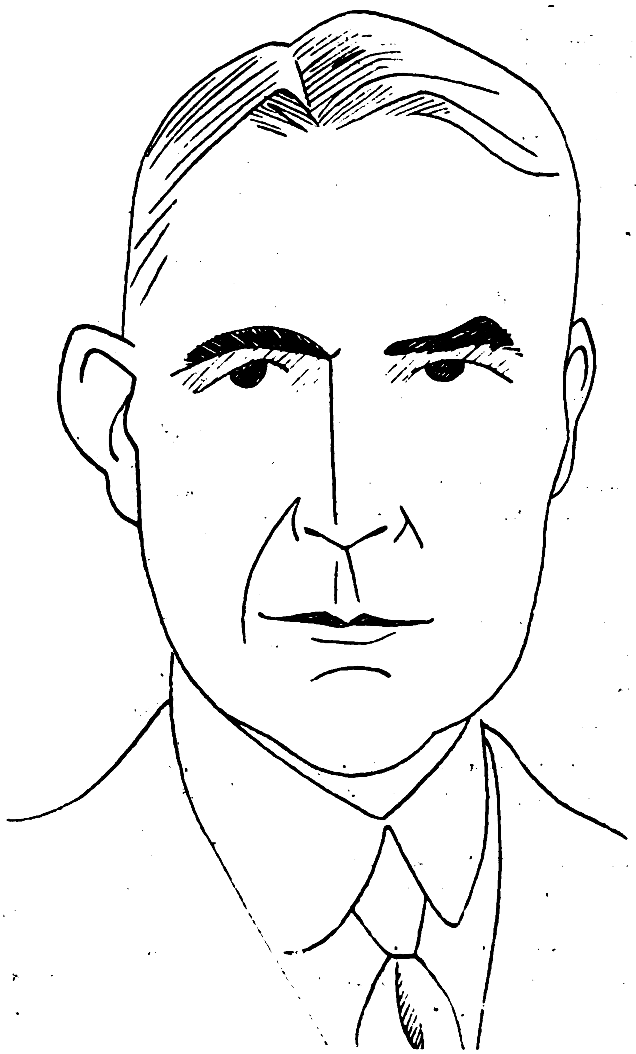


Above.—*Experimental work in the Germination of Tree Seed, by the School of Forestry, at the Green House of the Marsh Botanical Garden.*

P·E·R·S·O·N·A·L·I·T·I·E·S

No. 5. *CHARLES HYDE WARREN*

"FORSOOTH I am a wild, wayward youth." This was the characterization of Charles Hyde Warren, later to become Dean of the Sheffield Scientific School, that his classmates of '96 S saw fit to apply to him when he graduated at the tender age of 19 years. But the newer school of biographers would find this a false scent. A classmate speaking in retrospect says, "Warren was a serious, hard working boy. A good student—but not outstanding in other ways." To fill in the gaps in the picture let us delve further into that intimate record of the opinion of his youthful contemporaries, the '96 S classbook. Here we find that he received notice as a grind, as most versatile, most likely to succeed, most to be admired, and as best natured. But we find no mention of those less admirable qualities that youth looks upon so humorously and so lightly.



Warren as a student and Warren as a man, however, are two different individuals. As a youth he was facing his own problems and he concentrated his energy and resources on the solution. He had little inclination and found less opportunity to waste his time on the frivolous and the passing interest. But in working out his own salvation he developed the resourcefulness, the insight, and the breadth of vision that fitted him to take upon himself the problems of others. With the relaxation that followed success, however, came an opportunity for widening of interests, an appreciation of the company of his fellow men, a capacity for seeing "the funny side of things", an enjoyment of all the finer pleasures of life, and withal an ability to contribute to the pleasure of others. Above all he developed that great outstanding sympathy that is his principal trait of character today.

The present Dean of the Sheffield Scientific School was born September 27, 1876, the son of Frances Hyde and Charles Alanson Warren, at Watertown, Conn. He received the Ph.B. degree with the class of 1896 S and in 1899 took his Ph.D. also from Yale. From 1897 to 1900 he acted here as an instructor in mineralogy and in the fall of 1900 entered the geology department of the Massachusetts Institute of Technology where he served for 22 years, attaining the rank of Professor in 1912. During his years at M. I. T. he engaged actively in professional and expert work on abrasives and ceramic materials. But of much more significance were his duties as chairman of the Committee on Courses of Instruction, and he played a major part in formulating the program of that school following the war. It was in this work that he displayed those marked abilities as an educator and that sympathy with the modern liberal trend in education that have characterized his regime here.

In 1922 Warren was called to his present office. In commenting upon his appointment, the *Alumni Weekly* declared that the Corporation of the University had "preserved the traditions of this School in electing to the office of Dean one of its younger graduates who is in active touch with the educational problems of the present day," and that the Governing Board of the Scientific School had selected a leader who "has high administrative ability and is progressive, and has sound and sane views on educational policies."

It is interesting to note that Warren as the third administrative head of the School has much in common with its first Director, George J. Brush, both being good administrators and also distinguished mineralogists. It is also an interesting fact and perhaps significant that Warren received his training in mineralogy from Prof. Samuel L. Penfield, a man in turn developed by Brush.

On assuming his duties here, Dean Warren found a much different situation in Sheff. than exists today. The reorganization of the University in 1919 had left a certain amount of confusion. And it was his task to eliminate this as it affected Sheff. In addition he found the School still in the grip of the hide-bound dogmatic period of education. All courses of study were prescribed and there was little opportunity for a man to express his individual interests in choice of electives. But Warren came to Sheff with definite ideas in this respect which he had developed at M. I. T. He made the courses of study more elastic and put in the system of electives that is enjoyed today.

Dean Warren has many other activities outside of his official duties. He is Sterling Professor of Geology and is a member of the Board of Control of the University Athletic Association. His scientific interests are wide, and he has published many

(Continued on page 42)

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

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G. S. MOORE, '27 S., *Assistant Editor.*

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CLARENCE BLAKESLEE, '85 S., Vice-President.
HENRY S. PICKANDS, '97 S., Second Vice-President.
BILLINGS WILSON, '16 S., Secretary and Treasurer.

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C. BLAKESLEE, '85 S.	E. E. MINOR, '96 S.	J. W. MARSHALL, '07 S.
H. S. PICKANDS, '97 S.	W. M. SANDERS, '99 S.	A. H. RUDD, '86 S.
B. WILSON, '16 S.	W. E. DOWD, JR., '00 S.	E. M. T. RYDER, '96 S.
F. C. PRATT, '88 S.	S. W. DUDLEY, '00 S.	R. H. MATTHIESSEN, '12 S.
B. STOUTON, '93 S.	E. M. HERR, '84 S.	C. TOWNLEY, '86 S.
H. T. HERR, '99 S.	C. J. LAROCHE, '18 S.	

Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

This department is prepared by the Yale Engineering Association. The Editors of the YALE SCIENTIFIC MAGAZINE are not responsible for its contents.

RECENT ACCOMPLISHMENTS

1. Erection of Engineering Camp at East Lyme, Conn., giving Yale the best of its kind in the world.
2. Erection at Bowl of Memorial Tablet to the designer, Charles A. Ferry, '71 S.
3. Having University authorize Committee on Architectural Plan to prepare preliminary sketches for new building to replace South Sheffield Hall.
4. Co-operating with new Yale Scientific Magazine by subscribing for copies to be sent to every member of the Association.
5. Representing in an organized way the Alumni of "Sheff" to help the Faculty and University solve many problems for the best interests of Yale.

MINUTES OF THE THIRTEENTH ANNUAL MEETING AND DINNER, YALE ENGINEERING ASSOCIATION, HELD AT THE YALE CLUB, NEW YORK CITY MARCH 28, 1928

The Annual Meeting and Dinner of the Yale Engineering Association convened at the Yale Club, New York City, Friday evening, March 28, 1928.

There were present 170 members and guests including 9 members of the faculty and 91 engineering students of the senior class.

President Smith F. Ferguson, '94 S., called the meeting and dinner to order at 7:30 P. M., and announced the appointment of Messrs. Sargent and Quarrier as tellers to collect and count the ballots.

During the serving of dinner a business meeting was held. Upon motion duly made, seconded and carried, the reading of the minutes of the last Annual Meeting was dispensed with and they were ordered approved.

The reports of the Secretary and Treasurer were then read and upon motion duly made and seconded were approved as appended hereto.

Mr. Quarrier reported for the tellers and announced that the following officers had been unanimously elected:

President, Mr. Smith F. Ferguson, '94 S.
First Vice-President, Mr. Clarence Blakeslee, '85 S.
Second Vice-President, Mr. Henry S. Pickands, '97 S.
Secretary and Treasurer, Mr. Billings Wilson, '16 S.

The following were also reported as unanimously elected to be members of the Executive Committee:

To serve three years, until Annual Meeting 1931:

Mr. Alexander H. Rudd, '86 S.
Mr. E. M. T. Ryder, '96 S.
Mr. Ralph H. Matthiessen, '12 S.
Mr. Calvert Townley, '86 S.

To serve two years, until Annual Meeting 1930:

Mr. J. Waller Marshall, '07 S. (to succeed Mr. James Lyman, '83 S.).

To serve one year, until Annual Meeting 1929:

Mr. Edward E. Minor, '96 S. (to succeed Mr. Landon K. Thorne, '10 S.).

President Ferguson then called on Mr. Alfred Rheinstein, President of the Princeton Engineering Association, who made a brief address. He was followed by Dean G. Edwards, President of the Harvard Engineering Society, who also extended his good wishes to the Annual Meeting.

President Ferguson then introduced Mr. C. C. Zantzinger, '92 S., the first guest of honor who spoke on "Rebuilding Sheff". Mr. Zantzinger has been specially selected by the University authorities to prepare preliminary plans for a new building to replace South Sheff. He touched upon the problems confronting him as an architect in attempting to design a building that will fit in with a group plan for the future growth of Sheff. The location under consideration is the most prominent one in the City of New Haven and affords an opportunity for the finest vista of any university in the country.

Mr. Zantzinger then outlined in a general way what he thought the new building should look like. Because it is a building for a scientific school, which deals with modern principles, modernism must be expressed in the building. The building must not depart from our university traditions. The "Collegiate Gothic" type has been adopted by the University authorities; hence a building modern in form but in detail in sympathy with other buildings and a medieval motif in the detailed decorative embellishment. Lastly, a cut stone building, like others on the same corner.

President Ferguson then introduced Mr. J. B. Taylor, a research engineer of the General Electric Company, the other guest of honor. Mr. Taylor spoke on "The Transmission of Sound by Light" and gave a practical demonstration of the feasibility of this method of communication with special instruments which he had brought with him and erected at opposite ends of the dining room. He explained the theory underlying the formula and then turned on a phonograph at one end of the room, the sound of which was transmitted on a beam of light to a loud speaker at the other end of the room. Mr. Taylor then introduced his hands into the path of the beam, cutting it off and stopping the music and showed how, as he gradually withdrew his hand the music was increased in intensity to its original volume. These and other experiments with the photo electric cell made up a most interesting and instructive talk.

The meeting adjourned at 9:30 P. M.

BILLINGS WILSON,
Secretary.

MEMBERSHIP DRIVE

Through our membership drive in 1927 we obtained 295 new members. We also secured 100 new members from the class of 1927 S., making a total of 395 new members obtained in 1927. We lost through deaths, resignations and otherwise 66 men in 1927, showing a net increase of 329 members.

At the close of the year 1926 we had	1,117 members
At the close of the year 1927 we had	1,446 "
From January 1, 1928, to date the Membership Committee has secured	137 members
Total membership as of May 12, 1928	1,583 "

USE THE COUPON

BILLINGS WILSON,
75 West Street,
New York City.

I hereby propose for membership in the Yale Engineering Association. If this application is approved, he agrees to abide by the Constitution and By-Laws of the Association, and to further its objects in every way in his power.

Name ....

Class ....Course............ Degree.............

Mail Address ....

....

Occupation or Position ....

Business Connection ....

Business Address ....

....

Signature of proposer ....

Date ....

Following is standing of Sheff Classes, in % of Class who are Members of the Yale Engineering Association as of *November 1st, 1927:*

Class	*% Members Y. E. A.*	*Class*	*% Members Y. E. A.*
1869	67	1908	15
1856	50	1871	14
1861	50	1876	14
1922	41	1879	14
1884	35	1882	14
1868	33	1891	14
1883	31	1905	14
1923	30	1910	14
1894	30	1913	14
1902	28	1877	13
1924	28	1878	13
1880	27	1912	13
1881	27	1889	12½
1899	26	1875	12
1896	25	1909	12
1870	25	1914	12
1865	25	1915	12
1885	23	1919	12
1886	23	1903	12
1888	23	1895	11
1890	23	1898	11
1925	22	1920	11
1926	22	1873	9
1916	19	1917	9
1921	19	1874	8
1893	18	1918	7
1897	18	1854	0
1906	18	1855	0
1907	18	1862	0
1887	18	1863	0
1900	17	1864	0
1892	16	1866	0
1904	16	1867	0
1911	16	1872	0
1901	15		

Every Member Get a Member—Do It Now—Watch Us Grow.

NEW EDITION OF WILLARD GIBBS' WORKS

Writings in Two Volumes to Be Published This Year: Commentary Relating Theorems of Gibbs to Actual Experimental Data Also Proposed

IN 1906 the writings of Willard Gibbs were printed in a collected edition of two volumes entitled "The Scientific Papers of J. Willard Gibbs," compiled and edited by the late Prof. H. A. Bumstead and Prof. Ralph G. Van Name, who is a nephew of Gibbs. Volume I contained all the papers on thermodynamics, and Volume II the remainder of his published writings with the exception of the book "Elementary Principles in Statistical Mechanics," which had been published only five years earlier and was at that time still available. At present both Volume I of the "Scientific Papers" and the volume on Statistical Mechanics are out of print.

In connection with a movement started last winter to establish at Yale a memorial in honor of Willard Gibbs, provision has been made, through the generosity of a donor who prefers to remain anonymous, for a new and complete edition of Gibbs' writings. This will consist of two volumes, well printed and bound, and will be sold at a moderate price to encourage wide distribution. Arrangements for this edition have been practically completed and it will probably be published during 1928. The committee in charge consists of Prof. W. R. Longley and Prof. R. G. Van Name.

In addition to the reprinting of the original text of Gibbs' works it is proposed to publish, at some later date, a volume or volumes designed to bridge the well recognized gap between the theorems of Gibbs on the one hand and the actual experimental data of the chemist and physicist on the other. This supplementary material, to be written by competent authorities in the several fields, would aim (a) to explain the philosophical background of Gibbs' method; (b) to amplify the treatment of points of special difficulty; (c) to discuss the evaluation of Gibbs' functions in terms of directly measurable quantities, and (d) to furnish a variety of illustrative examples from the literature now available. Such treatment is most needed in the case of the thermodynamic papers, but the plan may be extended to cover Gibbs' writings on other subjects if it seems expedient. The proposal is now being studied by a special committee and will be carried into effect if it proves practicable.

Astronomy

The Corporation has authorized the erection of an addition to the main observatory building. This will provide for additional office and library space. The addition will also include a lecture room capable of seating about fifty persons. This will be used chiefly in connection with the public nights at the observatory. If one of these nights should turn out to be so cloudy that the telescope can not be used, visitors will be taken into the lecture room where there will be an exhibition of lantern slides of all the more important celestial objects.

Mechanical Engineering

The Mason Laboratory machine shop has just made and calibrated a Fifth Wheel Tachometer for accurate measurement of automobile speed. The mechanism is operated by a bicycle wheel attached by a hinged arm to the running board, which drives a magneto and registers miles per hour on a meter in the car. The instrument is portable and can be attached to any standard make of car. Its applications are in accurate measurement of speed in all road testing of automobiles. Castings for the tachometer drive were presented to the Department by the General Motors Research Department, who originally designed this instrument for test work at the Proving Grounds, Milford, Michigan.

Prof. W. J. Wohlenberg is Chairman of a new research committee recently appointed by the A. S. M. E. for the purpose of studying radiation and heat transfer in the boiler furnace.

Mr. L. E. Seeley, as a member of the Boiler Rating Committee of the American Society of Heating and Ventilating Engineers, attended the meeting of this committee with engineers of various boiler companies to discuss the "Code for Rating Low Pressure Heating Boilers", held at the Bureau of Mines, Pittsburgh, April 9–11.

Professor H. L. Seward recently represented the Fuel Conservation Committee of the Shipping Board, of which he is a member, at the sea trials of the M. S. *Wilscox*, one of the Shipping Board vessels recently converted from steam equipment to Diesel direct drive. Part of his class in Marine Engineering accompanied him on these trials.

In connection with the publicity program of the Propeller Club of the United States, Professor Seward recently gave a radio address on "How It Feels To Be An Engineer on the S. S. *Leviathan*". He is Chairman of the Board of Governors of the Propeller Club of the United States.

Botany

Professor Wieland has been elaborating a series on the petrified araucaria cones from Patagonia belonging to the Field Museum of Natural History of Chicago. The types are related to the Norfolk Island Pine and promise deep interest from the standpoint of the modern conifers. Professor Wieland has also carried much further a study of the very celebrated cycadeoid of the Zwinger Museum of Dresden, discovered in 1753. This work is in connection with the elaboration of our Yale Black Hills collection.

On April 19 Professor Wieland delivered the Jacob H. Schiff Lecture on "The Flowering Plants of the Mesozoic Age" at Cornell.

Physics

Assistant Professor W. W. Watson, formerly of the University of Chicago, has been given the same rank here and granted a two year's leave of absence to go to Germany on a Guggenheim Fellowship.

Dr. Russel S. Bartlett, Ph.D., Yale, 1924, who has been in England the last two years doing research work, was made Assistant Professor here and will return in time for the fall term.

At the recent meeting of the American Physical Society in Washington, D. C., Professor Zeleny read a paper on "The Distribution of Ionic Mobilities in Air".

Messrs. Beams, Lawrence, and Garman have succeeded in attaining a rotary speed of 6,000 revolutions per second by means of a top revolving on a jet of air. Attached to the top is a small mirror. The instrument is used to measure the lapse of time between the excitation of atoms and the emission of light. At the recent meeting of the American Physical Society a demonstration was given.

Mathematics

Professor E. W. Brown, who is on sabbatical leave this half year, recently returned from a three months' stay at Mount Wilson Solar Observatory in California. He expects to sail for England shortly.

Mr. H. L. Dorwart has resigned his instructorship in mathematics to accept a fellowship in the department.

Assistant Professor Oystein Öre has been promoted to an Associate Professorship of Mathematics; and Dr. L. T. Moore has been made Assistant Professor of Mathematics.

Associate Professor P. R. Rider of Washington University has been chosen Sterling Fellow in Mathematics for the year 1928–29. Professor Rider took his Ph.D. degree at Yale in 1916.

Biology

Word has been received from Professor Hanison, who is taking a Sabbatical year in Europe, that he expects to reach New Haven September 16.

Several members of the staff, among them Messrs. Coe, Woodruff, Baitsell, Buchanan, and Steele, expect to spend a considerable portion of the summer at the Marine Biological Laboratory at Woods Hall, Mass., where they will be engaged in various lines of research.

It is probable that Dr. Karl E. Mason, who recently took his Doctor's degree in the Biological department at Yale, and has since been Instructor in Anatomy at Vanderbilt University in Nashville, Tenn., will spend the summer at the Osborn Zoological Laboratory engaged in research with Dr. Baitsell on certain problems connected with the development of tuberculosis in the tissues of the Guinea Pig. This work is being done in connection with a grant from the Medical Research Committee of the National Tuberculosis Association.

The Society of Experimental Biology and Medicine of New York City held their annual out-of-town meeting at New Haven on May 19. The session was held in the Osborn Zoological Laboratory and a number of the New Haven members appeared on the program.

Electrical Engineering

Professors A. E. Knowlton and R. G. Warner presided as chairmen of the Local Executive Committee at the Fifth Regional Meeting and Student Convention of the Northeastern District of the American Institute of Electrical Engineers.

Geology

Professor H. E. Gregory, who has been on leave from the Department and in charge of the Bishop Museum at Honolulu, is now in this country. He will spend the summer in Arizona and Utah for the U. S. Geological Survey.

F. F. Osborne, who is to take his Ph.D. degree in June, will be in the Sudbury district, northern Ontario. during the summer, to conduct geological work for the Canadian government. Mr. Osborne has accepted a position in the University of Iowa, and will begin his duties there in the fall.

Robert R. LeClercq, graduate student in geology, will spend the summer in Idaho for the U. S. Geological Survey.

Dr. R. W. Brown has completed a study of fossil plants from the Green River Basin of Wyoming. His manuscript is to be published as a professional paper by the U. S. Geological Survey.
Dr. Brown is the author of a book entitled "Materials for Word Study." It is an etymological treatise which will be of especial value to scientists.

G. A. Cooper, who is completing the requirements for the Ph.D. degree, has accepted an appointment to the staff of Peabody Museum, where he will make a special study of some fine materials collected by Professor Schuchert.

Professors Agar and Flint will do investigational work in Connecticut during the summer. Professor Longwell plans to continue his field studies in Nevada. Mr. Waters will spend the summer doing geological work in southern Canada and northwestern United States. Professor Dunbar will make stratigraphic studies in Illinois and Nebraska.

Dr. M. R. Thorpe, assisted by other members of the Museum staff, has collected a number of excellent dinosaur footprints from the vicinity of North Branford. These footprints were brought to light by tunneling operations in connection with the construction of a reservoir by the New Haven Water Company.

Mining and Metallurgy

On April 17th and 18th Doctor Zay Jeffries, Consulting Metallurgist of the Aluminum Company of America, addressed the Graduate students in the Hammond Metallurgical Laboratory. Doctor Jeffries, in his first lecture, discussed the metallurgy of aluminum and its light alloys, laying particular stress on the causes of hardening of certain alloys by ageing and heat treatment. In the second lecture he reviewed the recent theories on the hardening of steel.

The annual mine inspection trip for the senior class in mining will begin on Labor Day in Sudbury, Ontario, Canada. Copper-nickel mines and treatment plants will be visited there. The party will then inspect silver mines at Cobalt and South Lorraine, Ontario, gold mines at Kirkland Lake and in the Porcupine District of Ontario, including The Hollinger, which is the largest gold mine outside of South Africa. On the return, stops will be made in the Rouyn District of Quebec, one of Canada's new copper-gold camps, and at the Chateaugay Iron Company and Witherbee-Sherman & Company iron mines in New York State. The party will be in charge of Professors R. K. Warner and H. A. Behre.

Professor Behre has recently been appointed a member of the Committee on Milling Methods of the American Institute of Mining and Metallurgical Engineers.

Chemistry

Professor Harry A. Curtis, Chemical Engineer, has been asked to serve as a representative of the Department of Agriculture at the World Conference of Agricultural Nitrogen Producers, which began during the week of April 30. He is abroad two months for that purpose. The representatives assembled at Venice for a cruise of the Adriatic during the conference.

The H. K. Mulford Company has established two fellowships in organic chemistry to be known as the Milton Campbell Fellowships in Organic Chemistry.
Professor George Barger of the University of Aberdeen, Scotland, gave an interesting lecture on "The Thyroid Gland and the Thyroxin" at the Sterling Chemistry Laboratory, on March 30th. The lecture was given under the auspices of the New Haven Section of the American Chemical Society and the University Department of Chemistry.

Forestry

Dean Graves recently attended the farewell dinner in Washington tendered to Colonel W. B. Greeley, who has resigned his position as Chief Forester of the United States Department of Agriculture. Colonel Greeley succeeded Dean Graves in this position in 1920. He is a graduate of the Forest School in 1904. The new appointee is Major R. Y. Stuart, a graduate of the Forest School in 1906. This carries on the series of Yale men in this important position. Hon. Gifford Pinchot, Yale '89, was Chief Forester from 1898 to 1910, and he was followed successively by Dean Graves, Yale '92, who held the post until 1920; then came Colonel Greeley and now Major Stuart.

Dean Graves contributed an article to the April number of the Journal of Forestry entitled, "Some Considerations of Policy in Forest Education."

Professor Garratt gave a talk before the Nylta Club in New York City on May 11, on the subject of "Insulating Materials in Building Construction."

Professor Hawley conducted a field trip on the afternoon of May 1st, for a group of State Extension workers in forestry, under State Director of Extension, Dr. Ellis. Representatives from the Extension service in the U. S. Department of Agriculture and from the Northeastern Forest Experiment Station at Amherst, Mass., were present in addition to the Connecticut Extension workers. The afternoon was spent on the Maltby tract, viewing thinnings and other cutting operations in hardwood stands of different ages. Approximately 5,700 cords of fuel wood and 1,000,000 ft. bd. measure of lumber and ties have been cut from this tract of about 1,200 acres in the forest operations during the last twenty years. As a result the forest is in much better condition and growing more rapidly than at the beginning of the period.

Approximately 120,000 red pine three-year old transplant trees have been set out this Spring on the properties of the New Haven Water Company under the direction of Professor Hawley. Most of the planting has been on the watershed tributary to the new North Branford reservoir. Some ornamental planting of hemlock, arborvitae, and red pine was also done near the new dam.

STUDYING THE STREET TRAFFIC PROBLEM

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traffic of an impending change in signal aspects—the amber light not being used to warn standing vehicles. The platoon type of operation controls the speed of the vehicles and hence prevents unauthorized speeds.

As a check on the operation of the platoon type signals, questionnaires were recently sent to a number of motorists who were found from traffic tallies to be using the thoroughfare now equipped with signals of that type. These signals are set for a vehicular speed of twenty miles per hour. Thirty-three replies were received, and, with the exception of one motorist, all agreed that the present method of signalling is an improvement over the former type, i.e., the so-called synchronous where the signal aspects were all permissive at one time or all prohibitive at one time. The following two comments show the general trend:—"This system prevents speeding, saves shifting gears and applying brakes and prevents blocking of traffic at signal corners;" and, "It speeds up traffic, and at the same time it prevents those who are inclined to 'step on her' from excessive speeding, therefore requiring less surveillance by police."

The satisfactory solution to any problem presupposes a minimum of disturbance, financial and otherwise, to all parties concerned. Yet it is not apparent at this time how conflicting ideas on traffic regulation and control can be reconciled without a "give and take" attitude on the part of each and every interest. The point to be brought out here is that ingenuity, if properly applied, will develop other ideas which will eventually lead to the most beneficial changes possible. Improvement in street pavement, the institution of parking restrictions, and the use of automatic signals where the amount of traffic is sufficient to warrant their use will undoubtedly result in the procurement of alternate routes which will serve to "dilute" the traffic which is now more or less concentrated on a few thoroughfares.

Slow-moving vehicles obstruct traffic, diminish the number of vehicles that can pass a given point in a given time and increase the practice of one vehicle passing another, thus adding to confusion and danger. Certain vehicles, such as heavy trucks, which inherently must proceed at slow speed, are required to travel close to the curb. This requirement is fairly well observed but fails to solve the problem of interference with free movement.

Street cars using the natural highest speed lane and operating on a local stop service become slow speed vehicles and, in view of the ordinance requiring other vehicles to stop with them, have a very definite retarding action on all other vehicular movements.

To promote the condition of "fluid" traffic movement which does not *per se* induce speeding but does to all intents and purposes tend to satisfy the "get there" urge, the Detroit Report suggests the use of a gridiron of progressively timed signalled routes and, on at least the main thoroughfares where streetcars operate, that the street cars operate as express units, stopping approximately once to the mile, while busses carry local passengers—transfer between the two types of vehicles being permitted without additional cost to the rider.

Need for Concentrated Transportation of Commuters.

Where there is a reasonable amount of street space available for all types of vehicles, the traveler should be allowed to exercise his option as to the type he prefers. But where, for economic or other reasons, it is deemed necessary to curtail the use of the automobile, every consistent effort should be made to substi-

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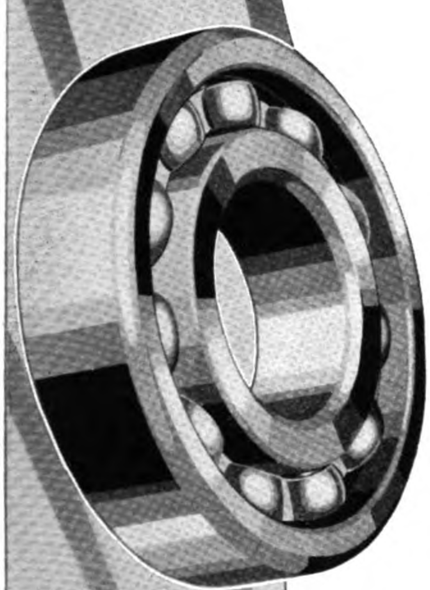

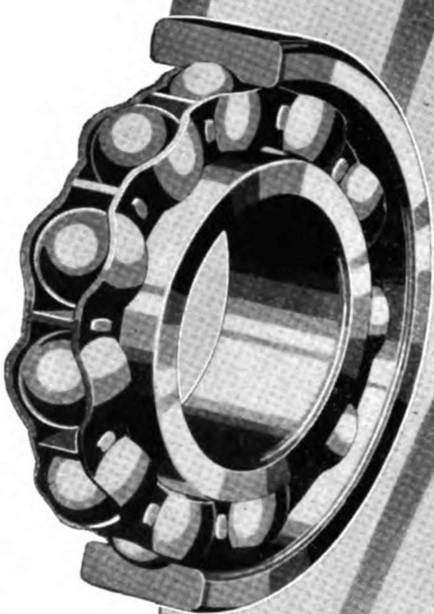

STUDYING THE STREET TRAFFIC PROBLEM

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tute a service comparable in speed and comfort to that curtailed. In other words, if comfortable seats and a speed of 15 miles per hour in the business district and 20 miles per hour in residence districts are the drawing cards in the use of the automobile, then the same features should be incorporated in the vehicles which for economy of space are desirable operating units.

Many people avail themselves of automobiles to provide transportation to and from the business district and in so doing use street space out of proportion to their numbers. A continued increase in this disproportionate use leaves just that much less space for street cars and buses which are economical of street space.

It is assumed that the merchants and property owners in the downtown business area are interested in the procurement of efficient transport to and from that area. It is further assumed that such interest is not confined to them but is distributed throughout the metropolitan area and even into suburban territory. If such is the case, plans should be made to purchase additional mass transportation vehicles; and induce the use thereof through attention to the elements of speed, comfort and the shortest and most direct routes.

Commercial Traffic an Important Item.

As a means of reducing the number of vehicles using the streets, it has been proposed in some cities to confine freight pickup and delivery to the night hours, insofar as practicable. This proposal has very attractive features and the time may come that necessity will force its adoption—this necessity in turn being more or less a function of the cost of operation, i.e., it will have been determined by trucking interests, the railroads and the merchants that, taking into account all factors, it is more economical than day delivery.

Night pickup and delivery of freight should be given some thought and studies made to determine its potential economy-increasing possibilities.

Representatives of several trucking interests have stated that the efficiency of their outfits is about two-thirds of what it was ten years ago, due for the most part to the time lost in procuring loading and unloading space in alleys or at the curb because of the use of the same by private automobiles. The inability to procure such space results in "cruising," double and, at times, triple parking in streets where space is at a decided premium.

In many instances, the duration of double and triple parking is considerably lengthened because of the necessity for truck drivers to make pickups and deliveries above the first floor of buildings. If a plan could be devised whereby this feature could be dispensed with, it would have a two-fold action: a reduction in duration of double parking and a reduction in thefts of merchandise while the driver was absent from his truck.

Private automobiles parked in alleys are also responsible for lost truck time because of the necessity at times for moving the same before the truck can load or unload. In addition, collisions between trucks and parked automobiles in alleys have been a source of considerable loss both to the truck operators and to the insurance companies. The self-evident results of these conditions can be none other than an increased cost in the handling of merchandise.

Reference has been made to the desirability of producing "fluid" traffic movement through a reduction in the amount of valuable space allocated to parking of vehicles. There is another form of "street abuse" which has a deleterious effect on traffic movement—that of a "moving parking" or "cruising" as it is generally termed.

The taxicab, which is responsible for a good share of the "cruising" has a very definite and useful position as a transportation unit. Its field of activity is ever broadening and the number of taxicabs is on the increase—the Detroit registration having increased from 254 such vehicles in 1921 to 1301 in 1926.

Because of the evident demand for taxicab service, full recognition should be given to it, but such recognition should not be one-sided, i.e., the taxicab interests should recognize an obligation to be as little of a nuisance as possible. "Cruising" can be classified as a high-class nuisance and a very distinct obstruction to traffic movement and because of that fact should not be tolerated.

Because of the limited amount of space available for one-hour parked vehicles, it does not seem altogether reasonable to reduce that space to any great extent in converting it to for-hire vehicle space. On the other hand, cruising vehicles are definite traffic obstructions and the practice should be curtailed as much as possible. This applies to private automobiles as well as taxicabs.

Where "off street" parking space is available adjacent to the origin of taxicab business, street stands should not be permitted. Where such space is not available, additional space might be assigned for taxicab stands for the benefits to be derived from a reduction in taxicab "cruising."

The Pedestrian Side of the Traffic Problem.

Of all the phases of street traffic, without doubt that of pedestrian control is the most difficult for which to prescribe a remedy. The pedestrian in full recognition of his own safety and of the efforts made for his safety, invariably inisists on exercising his inalienable rights to govern his own actions either on the sidewalks or in the roadway.

It has been said that if vehicular traffic was permitted to function in a manner similar to that elected by pedestrians, highways would be in a hopeless tangle. Some municipalities have attempted pedestrian control through the medium of ordinances with penalties for infractions thereof, while other cities have tried giving the pedestrian a right of way at all times.

Where pedestrian control has seemingly been impossible, other means have been suggested, such as pedestrian subways, overhead bridges, and schemes of a similar type, all of which cost money, require considerable time for installation, and are only justifiable when the traffic density, pedestrian, vehicular or both, is so great as to preclude the adoption of any other course.

Even though pedestrian subways and bridges were the only means available for providing a solution, it is manifestly impossible to construct them all at one time for physical and financial reasons. In addition, it is not a foregone conclusion that pedestrians would use them unless there were no option in the matter or else the subways were so attractive structurally that people would want to use them. For instance, the mere construction of an underground passage without special attention being given to illustration, ventilation, easily negotiated approaches, personal safety of the users and proper location of subway entrances would most certainly not fall under the heading of attractiveness. Therefore, it would seem reasonable to decide upon a location for one pedestrian subway, design the same with regard to the items enumerated above, place it in commission and then carefully check the results.

A suggestion has been made that pedestrian movement at heavily transversed locations could be controlled if attention were paid to two things: (1) a division of the crosswalk into right and left hand lanes and, (2) the use of an automatic de-

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CANADA NORTH OF 56°

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magnificence of these celestial pageants of colour, often covering nearly the entire dome of the sky, baffles description. The silent stately movements of the great belts, streamers and pencils of delicately tinted light, give to the northern nights a mysterious and spectacular beauty unknown in southern latitudes. The snow, which follows not far behind the first displays of the Aurora, gives a perfect setting to these gorgeous exhibitions of colour. With the snow come frozen trails and streams and the ease of travel over the icy roads furnished by streams and lakes and the trails hardened by frosts. The emigrant who comes to northern Canada from the Central or Middle Atlantic States or southern Europe will exchange a winter environment of occasionally frozen mud and a bare, drab winter landscape for the cleanliness, healthfulness, and beauty of the White North. Allies of cleanliness and health comparable with the powdery snow and low temperatures which prevail for half the year in northern latitudes are unknown elsewhere. They completely bar from northern Canada malaria, hookworm and numerous other diseases common to southern latitudes. The complete immunity to many germ diseases, which the northern climate gives, more than compensates for its winter severity.

Conclusion.

For three hundred years emigration and civilization in North America has been moving toward the setting sun. During the next hundred years this movement will be as steadily toward the midnight sun as it was towards the sunset throughout the last three centuries. The nearly complete occupation of the good vacant land in the United States and southern Canada has already started this northward movement. Since the "Great West" has filled up, its long-potent lure will yield to that of the Great North. How great a part the development of aerial transportation will play in stimulating the future northward movement of population in Canada cannot yet be clearly forseen, but that it will be comparable with the influence exercised by railways in peopling the West during the second half of the last century can hardly be doubted. The aeroplane and radio may be expected to encourage the settlement of northern Canada in somewhat the same way as the transcontinental railways of an earlier period helped to open the West to civilization.

We are still, however, in a period when the public gives more credence to unfavourable than to favourable opinions of sub-Arctic Canada. With reference to the possibilities of our northern empire the average man probably feels somewhat the same uncertainty that the average Englishman felt in the first quarter of the 17th century about the future of the New England colony. The tales of hardship sent back to England by the Plymouth colonists who barely escaped starvation during their first winters in the New World must have sadly shaken the faith of John Bull in the future of a country so desperately cold as New England.

If we look up the antecedents of the men who have painted the horrors of an Arctic winter in the darkest colours we are apt to find at least a partial explanation in their previous environment. Kane, one of the explorers of the Arctic archipelago, who had some unpleasant experiences, including a thousand-mile drift among the ice-floes, tells us that he was enjoying the seashore life in the tropics when orders to join an expedition to the arctic reached him. Is it any wonder that the hardships of the North have the prominent place in his writings which we might expect sunstroke and torrid heat would have in an Eskimo's description of New York city? In Stefansson we see the effect of an antecedent environment and heredity just the opposite of Kane's. Stefansson is probably telling the real truth when he states that his greatest winter adventure was near his father's barnyard in North Dakota when he became lost during a blizzard and barely escaped freezing. In the Far North he reports having failed, after several years' search, to discover the climatic rigours or the hardships of many previous explorers, but found everywhere the "Friendly Arctic". In giving him this viewpoint toward Arctic Canada, Stefansson's Icelandic ancestry and his boyhood environment in Manitoba and North Dakota are undoubtedly strong factors, but there is not much doubt that it is a far truer and fairer estimate than the one we find in the writings of such an author as Kane. Other members of the Canadian Arctic Expedition have published little about their observations on Arctic climate but it is a rather significant fact that a member of this expedition who entirely escaped from frost bite during several winters spent in Arctic Canada, froze his ears the first winter after his return to Ottawa.

As a teacher of thrift and industry, Old Jack Frost has no peer. The happy-go-lucky ways of southern climes will not be tolerated in his domains. Those who are diligent in acquiring these fundamentals of a full and useful life are nearly certain to be rewarded with vigorous health, if not with wealth. The certainty of having to provide against occasional winter temperatures of 40° or more below is more effective than any statute in keeping out of northern Canada the mollycoddle and other undesirables. In the virile verse of Service:

"This is the law of the Yukon and ever she makes it plain.
Send not your foolish and feeble; send me your strong and your sane."

A land with a frontier guarded by so searching a critic of immigrants as Jack Frost, must be expected to grow slowly like the oak, and with the same strength of fibre. But it is destined to acquire a population which will eventually be large and show the fine qualities which another northern land implanted in the old Vikings of Norway.

If there are no new continents for these northern Canadians of the future to discover there will be new worlds of science, literature, and the field of human progress awaiting exploration and conquest. The ideas which can "raise men out of the world of corn and money" are the most valuable products of any country. We may expect a land which feeds the imagination and fancy with nightly displays of the Aurora Borealis to mother a race of men who will find pleasure and inspiration in the phenomena of nature and the northern "sea that bares her bosom to the moon". The Arctic cost of Canada may yet produce poets who

"Have sight of Proteus rising from the sea
Or hear old Triton blow his wreathed horn."

The centres of Canada's industrial and intellecutal activity will not remain on the southern border of the country. Science, literature, and the arts can flourish in the northern part of Canada as they do in northern Europe. It was north of 56° in the Old World that Linnaeus, the father of modern biology, and that amazing genius, Swedenborg, first saw the light; and we may reasonably expect that the high latitudes of our Dominion will furnish comparable contributions to the future intellectual wealth of the world.

STUDYING THE STREET TRAFFIC PROBLEM

(Continued from page 34)

vice that, in connection with the green signal aspect, would indicate how much time was available during the display of the green signal for pedestrians to start across, taking into account the *total* time required.

One phase of pedestrian control which has not been given the attention it merits is that of locating signals, which pedestrians are expected to obey, such that the signals are in *their direct line of vision.* Only in exceptional cases will pedestrians watch the signal aspects if it requires the slightest physical effort so to do. An acknowledgment of this fact might just as well be made and signal systems arranged so that this feature is taken care of, even though it may call for additional equipment.

Recapitulation.

Traffic control and regulation is a problem in economics. There is altogether too much at stake both in the efficient use of time and money and in safety to the public, to permit the establishment of traffic policies on opinion or theories. What may be food for one interest, may be poison for another. It may not be possible at this time so to arrange the direction of traffic to suit everyone, but it should be possible to affect a compromise arrangement that would redound to the benefit of the big majority.

The Detroit Police Department has made a traffic survey and is now attempting to derive some benefits from it by following up the suggestions made; and where the suggestions have been placed in effect, checking up the results therof.

COMMERCIAL AVIATION IN THE UNITED STATES

(Continued from page 20)

manufacturers will produce structurally unsafe airplanes, for the public will soon come to expect approved type certificates with the bills of sale which accompany their purchases. Steel tubing fuselage construction and other improvements in building of airplanes have already decreased accidents from these causes. Few airplanes now fail from structural defects.

The mechanical failure from stopping of engines is being greatly decreased with the use of modern efficient aircraft engines, such as those which have made possible the great records of the past year.

The human element is found in every form of transportation and will continue to exist in flying, but the knowledge that pilots are under regulation and subject to revocation of their licenses will reduce this to a minimum.

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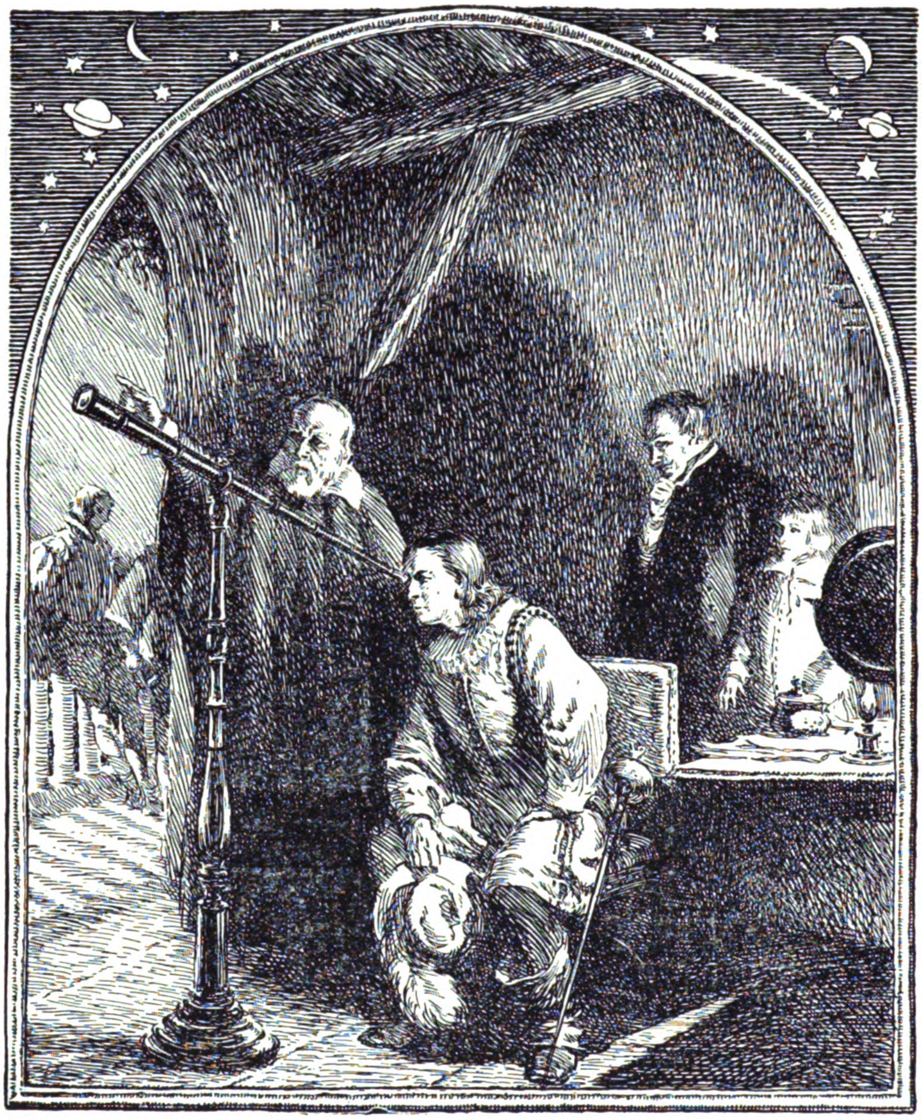

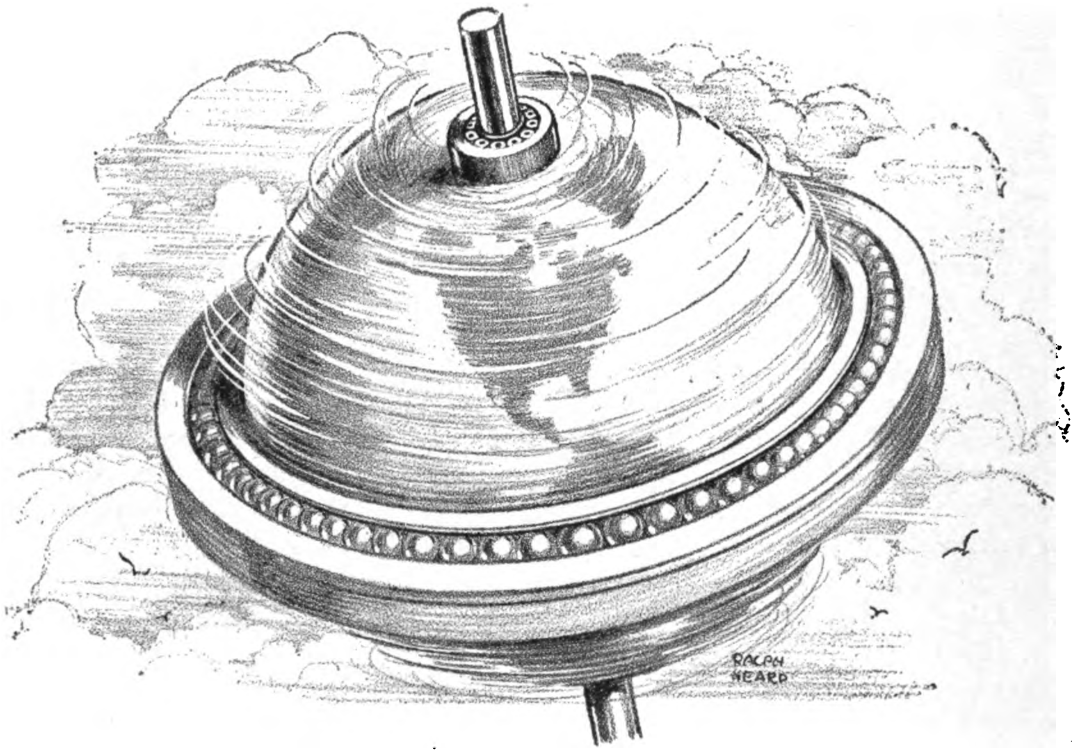

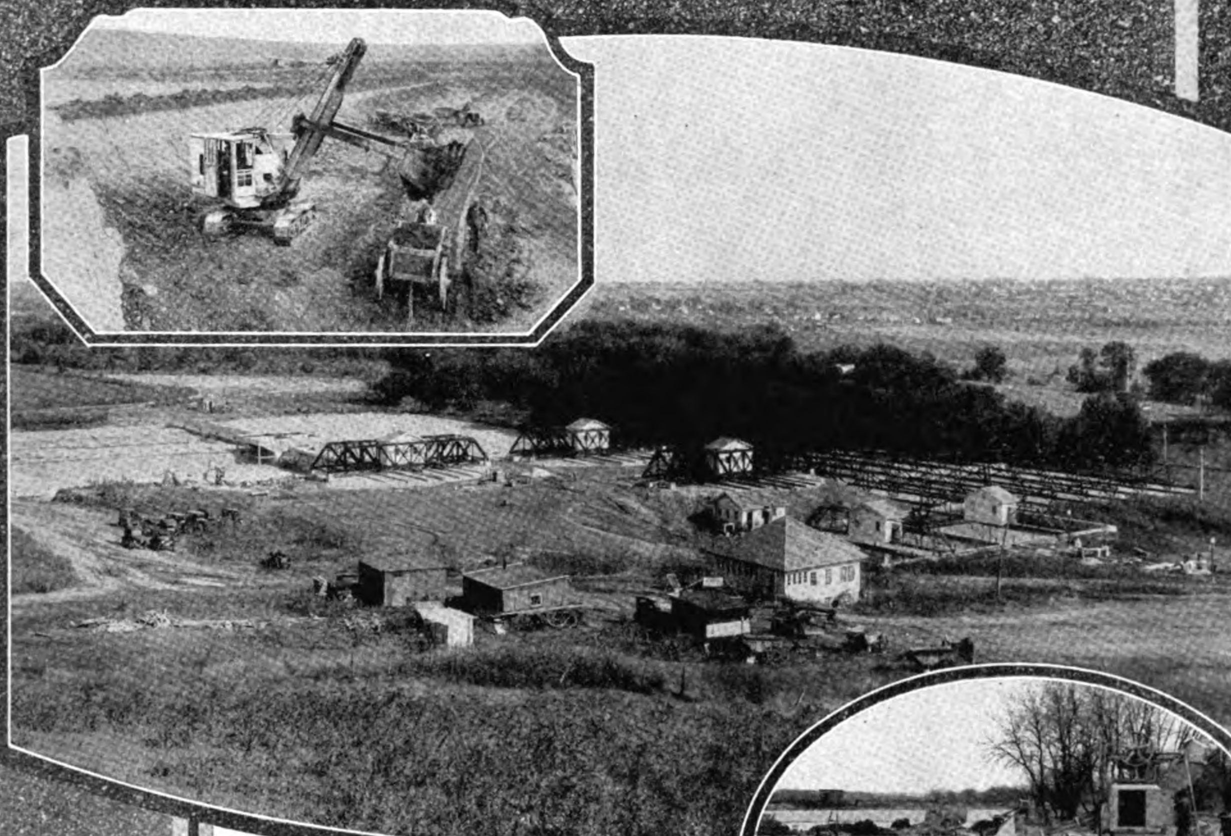

PERSONALITIES

(Continued from page 27)

papers on chemical, mineralogical, crystallographic, and petrologic subjects in various scientific journals. Since 1926 he has served on the committee which conducts the affairs of the *American Journal of Science*, and he is a member of numerous scientific and other societies.

He was married on June 17, 1903 in Watertown, Conn., to Charlotte Wardner Lamson, and they have three sons. During the school year the family resides in New Haven but as soon as the summer vacation frees him, withdraws to the quiet of a farm in Litchfield. Here he has a chance to devote himself to his hobbies. One of them is agriculture— and friends have it that he is an expert with the hoe. But he is no common dirt farmer, for a fine apple orchard gives him the right to dignify himself with the title of horticulturist. Another hobby is restoring antique furniture and the hours he spends at his work bench are productive of astonishing results. Another interest that occupies much of his leisure is a study of the history of science and the lives of scientific men, and he has worked up considerable interesting material which may some day find its way into print. There are whispers that fellow club members know too well of a fourth hobby at which he is an adept—but who can say?

In his contacts with the students, the Dean is seen at his best. His keen understanding of the psychology of the student mind and deep sympathy with their problems make an excellent combination in dealing with the undergraduate. What has been described as "his extreme frankness" is another decided asset. He realizes the hygienic value of thoroughly "airing" a situation and he is seldom loathe to do so. These qualities along with a well-developed sense of humor have won him the confidence, respect and friendship of every Sheff. man.

COMMERCIAL AVIATION IN THE UNITED STATES

(Continued from page 37)

The weather has been until recently one of the worst obstacles in the path of developing commercial air transportation. Efficient instruments, however, have made it possible for experienced pilots to fly for hours without a sight of ground or sky. Experiments are now being made to reduce the danger of ice formation on wings. The radio beacon has already been developed to guide pilots through fog and other conditions of reduced visibility. With the advent of radio markers and an altimeter which will show the true height above the ground instead of the height above sea-level, flight under these most adverse conditions will be made much safer.

Training schools will in the future teach their students blind-flying just as they now are beginning to teach them how to make night flights, which were once considered hazardous and inadvisable.

The industry itself under the impetus of the past year's popular interest has forged an incredible distance to the front. With the continued support of the public and under the proper guidance of Federal and State authorities it will attain new heights within the next few years and the commercial aviation of this country will undoubtedly lead that of all countries within a comparatively short time.

AMERICA'S PLACE IN MINING

(Continued from page 18)

nickel; and the valuable metal, tin; the U. S. production is generally about half that of the world. (2) The growth of metal production particularly in the United States and Canada during this thirty year period has been great. The world considered itself a large metal consumer in 1897 and yet of the fifteen mineral products listed only one, platinum, has declined, one other, silver, has increased only 50%, the others show increases ranging from nearly 100% for gold to 6000% for aluminum, 1000 for nickel, and 900 for petroleum. (3) Most metals show, as would be expected, a high point in 1917, the peak of the war production. The figures show that in ten cases out of the fifteen the latest world production is above that of the war peak. That the U. S. bore the brunt of the war load is shown by the fact that in seven cases our local production is below that for 1917. (4) Price increases have not kept pace with increased demand. In six instances the price is below that for 1907 and in six others the price in 1907 dollars would probably be lower.

It may be worth while to offer a word of explanation for each metal.

Aluminum. This metal is more of a manufacturing than a mining problem. As its value as a substitute for copper and iron and for any use where its lightness can compensate for its low tensile strength, unalloyed, has been appreciated, the demand has increased. Improvements in methods of production have actually reduced the price in spite of the increased demand. The United States has always been the leading nation in aluminum production although the figures show the growth of foreign competition, notably from Germany and Norway.

Chromium Ore. Ferro-chrome made from this ore is now one of the most important steel making alloys. It forms the basis for the so-called "stainless" steels. The use of chromium for plating parts where a bright, well colored, and extremely resistant plate is desired is a new and rapidly growing field for this metal. In the war emergency the United States produced a considerable quantity of chromium but since the war has been unable to meet competition from Rhodesia and India. The abundant supply has lowered the price below 1907 in spite of the increased uses.

Coal. Coal serves a double purpose being a fuel as mined and the raw material for the by-product coke furnace, one of the foundations of our large and growing chemical industries. Coal deposits are widely distributed over the world and the price per unit is so low that supplies must normally be used locally. For these reasons coal production is a rough measure of industrial activity. Large economies in the use of coal have been made in the last decade and these make this use of production figures of doubtful value. The rise in price reflects both the increase in wages paid by the industry and the increased benefits from the coal.

Copper. This metal is about the best example of the effect on the United States of the high productive capacity created during the war. Despite the growth of the electrical industry since 1917 the demand in the United States has not yet reached the war peak and both price and production have fallen. During the last decade foreign production, notably that from Chile, which is under American control, and from the Belgian Congo, has made progress at the expense of home producers.

Gold. Gold mining differs from any other kind since the nominal value per unit of the product is fixed by law. During a period of declining general prices this is an advantage since costs are falling. When general prices rise gold mining for the same reason grows less and less profitable. South Africa still leads the world in gold production. The Canadian output is growing as that of the United States declines. Much of the United States gold is produced as a by-product of copper and lead refining.

Pig Iron. Pig iron has long been considered the backbone of industry and shows a steady growth during the thirty years. Our latest production is about the same as in 1917. We still produce more than the rest of the world combined.

Lead production has increased everywhere not due to any new bonanzas but largely because newly developed methods of selective flotation have increased the output of known deposits. Lead production is related to that of zinc with which it is commonly associated. The increased price is the result of new uses; principally lead conduit for telephone cables and storage batteries for automobiles and radio sets. This new demand has greatly exceeded the increase in supply so that with the rising price older users of lead have had to adopt substitutes.

Manganese ore, like chrome ore, is an important factor in steel production. Our native supplies are small and at present cannot compete with foreign ores, notably those from India and Brazil.

Nickel, aside from its use as a coating on less resistant metals, is also used for the manufacture of nickel steel. Canada has in twenty years reached a practical monopoly from its deposits at Sudbury, Ontario. The war demand was so great that the productive capacity greatly exceeded normal consumption. Since the war the nickel producers have successfully increased the demand by urging the use of solid nickel fittings rather than nickel plated ones and by the development of new alloys such as permalloy and nickel cast-iron.

Petroleum is the present source of automobile fuel and also of lubricants. How rapidly the demand has grown is shown by the last 20 years during which the price has doubled and the world production multiplied itself by four. Over 75% of the petroleum is at present produced in the western hemisphere.

Platinum is but sparsely distributed over the world. The bulk of the production has come from Russia. Colombia is the only large American producer. South Africa production is growing and has caused a drop in price later than that shown in the table.

Silver is less important as a coinage metal than it used to be. Mexico leads the world as a silver producer. Much of the silver is obtained as a by-product from lead and copper refining.

Sulphur has replaced pyrite as a source of sulphuric acid, the basic acid in the chemical industry. American production by means of a process in which the sulphur is mined by melting it and lifting it to the surface with superheated steam through wells has superceded that from Sicily.

Tin is almost entirely lacking from North America. The Bolivian production is less than 25% that of the world. Cornwall in England, once the world's greatest tin mining district, is almost exhausted. The Malay peninsula and the adjoining islands produce most of our tin.

Zinc alloyed with copper forms brass. Much zinc is now used alone. The increased production is due to the same causes mentioned under lead above. Improvements in the metallurgy of zinc of late years have been great. Zinc is another of the metals where the United States is well supplied.

ENGINEERING STUDENTS MAKE INSPECTION TRIP

(Continued from page 21)

and also remained in Pittsburgh a day longer to go through the plant of the Westinghouse Electric and Manufacturing Company and the Duquesne Light Company. The trip of the Electrical group ended in Washington with visits to the Bureau of Standards, the Smithsonian Institute, and the National Academy of Arts and Sciences.

The students were afforded excellent opportunity to observe the widespread application of power to supplant almost every phase of manual labor; this was particularly evidenced in the elaborate conveying systems operating in every plant. The results of the comparatively recent safety campaigns that have been a feature of industrial development were seen along the whole itinerary as well as trends in employee representation, systemization of management, dispatch in routing, and application of new mechanical devices.

The trip, which is required for graduation in three engineering courses, performs an individual function in supplying the opportunity for men to see some of the best known industries in operation. It offers a privilege which is unique in that it probably cannot be equaled outside of Yale.

Upon two occasions the party was entertained by graduate bodies: the Yale Engineering Association gave a dinner at the Yale Club in New York and the Yale Alumni Association were hosts at a luncheon in Philadelphia. Many of the privileges were extended to the groups through the courtesy of University graduates while in every town alumni went out of their way to welcome the party. President E. M. Herr, '84 S., of Westinghouse, and President W. W. Atterbury, '86 S., of the Pennsylvania Railroad, were particularly generous in lending support.

THE YALE SCIENTIFIC MAGAZINE

VOL III. NOVEMBER 1928 No. 1

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Prof. Leigh Page

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Henry Gardner

Some Current Views of Nutrition
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New Electric Furnace Used in Steel Treatment
Prof. Wesley B. Hall

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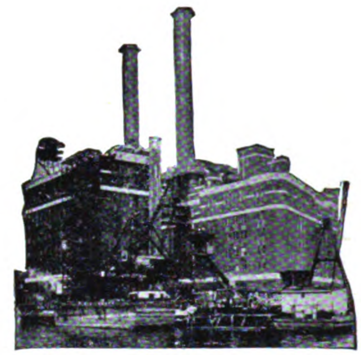

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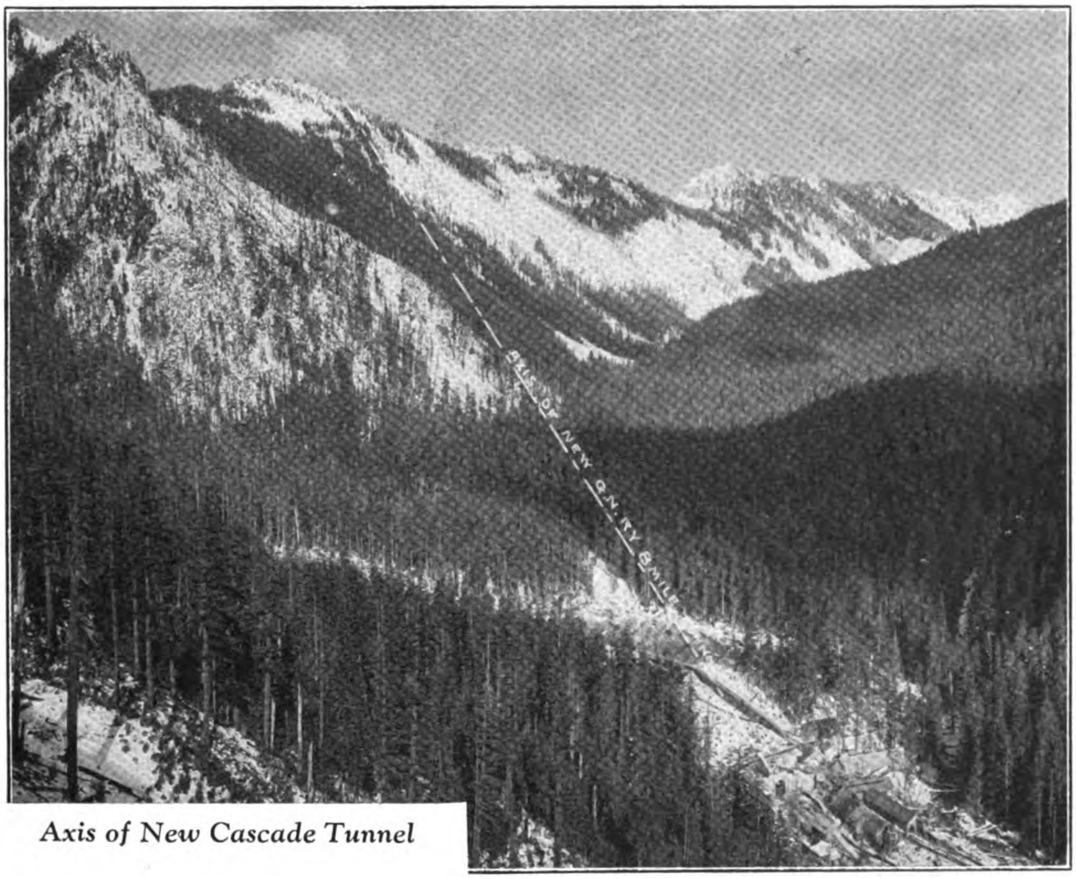

Axis of New Cascade Tunnel

THE YALE SCIENTIFIC MAGAZINE

C O N T E N T S

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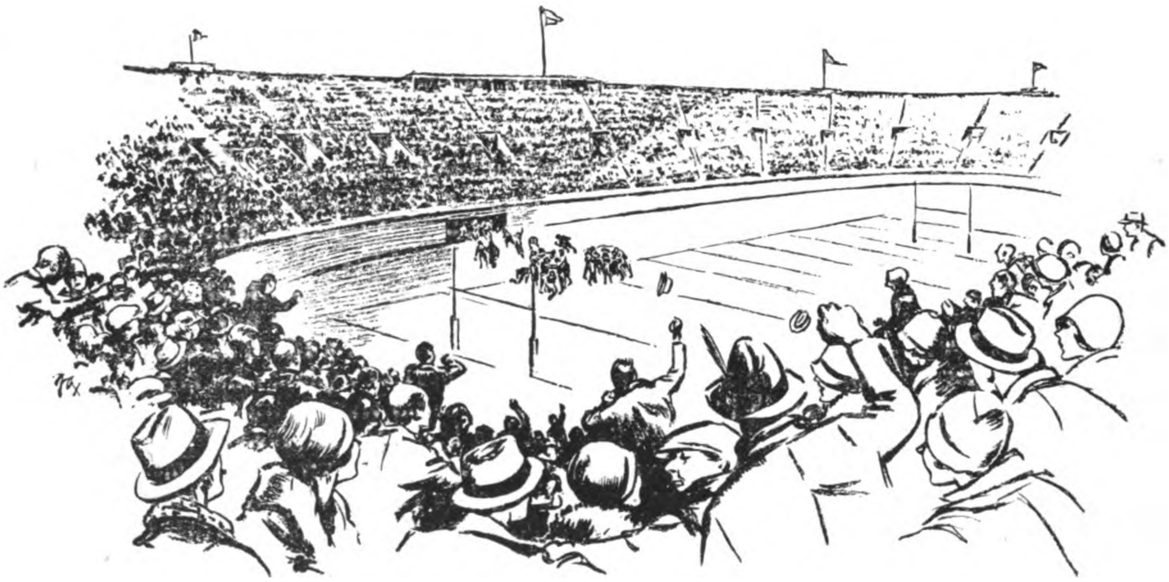


A Summary of the Principle of Relativity

A Brief Survey of the Important Phases of the Theory Which Has Had Far Reaching Effects on Modern Scientific Thought

By Prof. Leigh Page

FEW abstract scientific theories have attracted such widespread interest among both scientists and laymen as the principle of relativity enunciated by Einstein in 1905 in the restricted form and generalized by him in 1916 so as to make possible the development of his theory of gravitation. Lecat's "Bibliographie de la Relativité", published in 1924, lists 3775 works in 21 different languages on this subject, written by 1175 authors of 33 nationalities.

Inertial Systems.

The original pronouncement of 1905 is now labelled the "restricted" or "special" relativity in that it is limited to a consideration of inertial systems. Suppose that in our efforts to ascertain the regularities in the operations of nature—the so-called laws of nature—we make observations of the positions of the planets belonging to the solar system, as the astronomer Tycho Brahe did during the latter half of the sixteenth century. If we should tabulate the positions and velocities of the other planets relative to the earth for each day of the year we would find that we had accumulated a mass of data which exhibited so little regularity that any analysis of it would appear almost hopeless. In terms of our present knowledge we attribute these complexities to the fact that the earth itself is revolving around the sun in an orbit of ninety-three million miles radius with a velocity which changes by 36 miles a second in the course of six months. The attempt to analyse our immediate observations is comparable to the efforts of a boy on a swing to measure the height of a mountain with a theodolite without taking account of the motion of his support. If, however, we should refer our measurements to a set of axes attached to the sun instead of the earth, previously unsuspected regularities would become evident, and we should discover Kepler's three laws of planetary motion, and, if we possessed sufficient genius, Newton's law of gravitation.

RELATIVITY has become a byword in the English language during the last decade but there is hardly any term which is less understood. It has, moreover, come to occupy a paramount position in science and the newer philosophy. Feeling that at least a knowledge of the conceptions and the resulting conclusions is vital to any comprehension of modern thought, a summary of the subject by a man eminently qualified to write for the layman is here presented.

As our mental horizon widened, however, and we attempted to measure the proper motions of the stars, we should find that the sun is not an altogether suitable base of reference, for it is in constant motion relative to the stars as a whole with a velocity which is perhaps even greater than that of the earth relative to the sun. So finally we should be led to refer our measurements to a set of non-rotating axes whose origin remains fixed at the center of mass of the entire universe. This set of axes is known as the "primary inertial system."

The laws of dynamics, discovered by Galileo and formulated by Newton, specify the motions of bodies relative to the primary inertial system. These laws of motion, however, involve only accelerations and not velocities, and therefore they have the same form when the motions under consideration are referred to another set of axes moving with constant velocity relative to the primary set. If, then, we designate by the term "inertial system" any frame of reference which has a constant velocity relative to the primary inertial system, including the primary inertial system itself, Newton's laws of motion are valid for observations conducted in *any* inertial system. By no experiment of a dynamical nature is it possible to distinguish the primary inertial system from any other inertial system.

Before the advent of the relativity theory, however, it was felt that optical or electromagnetic experiments should be capable of revealing the existence of the primary inertial system as distinct from all other inertial systems. In order to account for the propagation of light waves through space devoid of material content physicists had invented a hypothetical all-pervading medium which they named the "ether." The ether was supposed to be located in the primary inertial system, and light waves were imagined to consist of undulations in this medium which travel through it in much the same way that earthquake waves are propagated through the elastic core of the earth.

In 1881 A. A. Michelson, now Professor of Physics at the University of Chicago, devised a very ingenious and delicate optical experiment to detect the drift of the earth through the ether. What was his surprise to find that the earth acted at all times of year exactly as if it had no motion relative to this hypothetical medium! This experiment, which has been repeated again and again by more sensitive methods, is the cornerstone on which the relativity principle is reared.

Special Relativity.

After several half-way proposals for explaining the unexpected result of Michelson's experiment had only complicated the existing ether theory, Einstein propounded the principle of relativity in 1905. According to this principle all inertial systems are placed on the same footing. Einstein assumes that no more by optical and electrical measurements than by dynamical experiments is it possible to assign to one inertial system characteristics giving it a preferred position over all other such systems. Acceptance of this proposal at once makes meaningless the concept of an elastic ether such as the British physicists had developed in great detail. For if the state of motion of the observer relative to the ether can never be ascertained, even ideally, the ether

can have none of the properties of an elastic medium for which it was invented, and therefore the whole usefulness of the concept falls to the ground.

Einstein's pronouncement at once came into conflict with established concepts of space and time. To illustrate this conflict let us consider two observers in different inertial systems. One, designated by E, we shall suppose to be standing on a railway embankment on the surface of the earth. (We are neglecting the rotation and orbital motion of the earth and taking it to be at rest in the primary inertial system). The other observer, T, we shall place on a railroad train traveling with velocity v along a straight track. As the two observers pass each other we shall suppose that one of them strikes a match. The light from the flame spreads out with the velocity $c = 186{,}000$ miles a second relative to the stationary observer. At the end of one second, it will have progressed 186,000 miles forward and an equal distance backward from the observer E on the embankment. But the train has moved forward a distance v during this time and according to pre-relativity ideas the traveler T would find that at the end of one second the forward moving light had advanced a distance 186,000 miles — v beyond him, whereas the backward moving light had receded a greater distance, 186,000 miles $+ v$. For such small velocities as those attained by an express train or an airplane these two distances are sensibly the same, but if we consider an observer traveling on a beta ray projected from a radioactive atom with a velocity of 150,000 miles a second or more the discrepancy is no longer negligible.

Our analysis of the problem fails to preserve the equivalence of the inertial systems E and T. In the former light travels with the velocity c in all directions; in the latter with the velocity $c - v$ in the forward direction and with the velocity $c + v$ in the backward direction. But according to Einstein's principle, if the velocity of light is given by the number c for all directions of propagation in system E it must be given by the same number c irrespective of direction when measured in the other system T. Now the velocity of light is the distance traveled by a pulse of light divided by the time taken. The only way we can satisfy the demands of the relativity principle is by providing our observers with different standards for measuring distances and time intervals than those contemplated by the older philosophy.

Consequences of the Theory.

Making the necessary adjustments of time and space measurements to insure the same constant value for the velocity of light in all inertial systems we are led to two very remarkable results. Let us take two identical yard sticks, hand one to observer E and the other to observer T, and ask the two observers to compare their yard sticks as they pass each other, holding the sticks parallel to the direction of their relative velocity. Each one finds that the other's yard stick is a little shorter than his own! At first sight such a statement sounds ridiculous, but a little consideration shows that it involves no contradiction. In measuring the length of a moving object it is necessary to determine the distance between the positions occupied by its two ends *at the same time;* if we locate the forward end at a little later time than the rear end we obtain too great a length, and *vice versa.* Measurement of the dimensions of a moving object is bound up with our definition of *simultaneity.* The apparent paradox is due to the fact that the two observers do not agree in their specification of "the same time," although each uses in his own system the same method of determining simultaneity as the other does in his system.

The other novel consequence of the relativity principle has to do with the measurement of time. If we furnish the two observers with clocks which run at precisely the same rates when relatively at rest, and ask each observer to rate the clocks in the other's inertial system, each would inform us that the other's clocks ran slow as compared to his own! Again we reach a contradiction which is only apparent and which disappears on analysis of the method by which a group of observers in a single inertial system rate a clock which is moving relative to them. For to rate a moving clock we must compare it with at least *two* stationary clocks as it passes by in order to find out whether it is running fast or slow. On the other hand an observer traveling with the moving clock must compare *one* of our stationary clocks with *two* of his in order to determine its rate.

The contraction of a moving rod and the slowing down of a moving clock increase with increase of velocity relative to the observer until dimensions in the direction of motion disappear and time comes to a stop when the velocity of light is attained. By cruising around the universe with the velocity of light Ponce de Leon could have attained perpetual youth! Returning to earth after traveling with this speed for a thousand years (as inhabitants of the earth reckon time) he would not have aged by one second. Unfortunately the time he was absent would have appeared to him as but an instant and his enjoyment of life would have been similarly curtailed. This type of perpetual youth, therefore, holds no allurements.

On account of the contraction in dimensions of moving objects Sirius seems to be touching the earth to a beam of light traveling from this distant star to us. This feature of the relativity theory, which was emphasized by Professor G. N. Lewis in the Silliman lectures two years ago, may have some bearing on the fact that recent discoveries in physics suggest that a light beam knows where it is going even before it starts.

In 1819 Oersted made the remarkable discovery that an electric current deflects a magnet and in 1831 Faraday and Henry found that change of magnetic flux through a circuit induces a current. While the laws of electromagnetism were soon formulated by Ampère, Neumann and Maxwell, it was not until the advent of the relativity principle that we were able to explain *why* a charge moving relative to the observer deflects a magnet suspended from his hand or a change of magnetic flux gives rise to an induced electromotive force.

On the relativity theory the mass of a body is no longer a constant characteristic of the body, but increases as its velocity is increasing, becoming indefinitely great as the velocity of light is approached. Therefore no finite force can ever give a body a speed as great as that of light. The relativity formula showing how the mass increases with the velocity has been verified experimentally, and the fact that the fastest moving particles known—beta rays projected from disintegrating radioactive atoms—have speeds almost equal to but never greater than that of light confirms the theoretical deduction of an upper limit to possible speeds. Furthermore the theory indicates that energy is proportional to mass, which has led to the supposition that the two are physically identical. Thus the astronomer has at last been able to explain the maintenance of an unimpaired flow of heat and light from the sun during untold eons by ascribing the production of energy to the transmutation of matter into radiation.

Minkowski's Four-Dimensional Representation.

In representing graphically the motion of a part of a machine, such as the piston of a steam engine, the engineer has been accustomed to plot the displacement against the time. The graph so obtained gives a complete picture of the motion, showing the position of the moving body at every instant of time and indi-

cating the speed at which it is moving by the slope of the curve. If we carry over this representation to the case of a particle which is moving along some complicated path in three dimensions instead of in a straight line, we need a four-dimensional graph in which the three coordinates x, y, z of the body are plotted against the time t. Now Minkowski showed in 1908 that if we represent the history of a moving particle by such a graph or "world-line," using $ct\sqrt{-1}$ in place of the time for the fourth coordinate, then the transition from the point of view of an observer in one inertial system to that of an observer in another amounts to nothing more than a rotation of the space and time axes in the four-dimensional representative space. Observers viewing the motion of a particle from different inertial systems would construct identical world-lines in describing its motion, but they would resolve their world-lines differently into space and time components. While one would say that the particle moved a long distance in a short time, the other would say that it passed over a short distance in a long time. Consequently, in Minkowski's famous words, "space in itself and time in itself sink to mere shadows and only a kind of union of the two preserves an independent existence."

General Relativity and Gravitation.

So far we have confined our attention to the restricted relativity which deals only with observers located in inertial systems. We have noted that the laws of dynamics gave the first suggestion of the equivalence of all inertial systems. So, too, dynamical phenomena led Einstein as early as 1911 to suspect an equivalence between an accelerated frame of reference in a field-free space and a gravitational field. Consider an observer placed in a box with no windows through which he can view outside objects. We will provide the observer with all the physical apparatus he desires and ask him to find out, if he can, whether or not he is located in a gravitational field. Placing the box gently on the ground we will leave the occupant to the use of his instruments and his wits, and await his report. Probably the first experiment the prisoner would attempt would be to see if objects dropped from his hand fall to the floor of the box. A little investigation would show him that all bodies fall with exactly the same acceleration of 32 ft. per sec. per sec. His first impulse would be to conclude that his box is at rest in the earth's gravitational field. Reflection, however, would convince him that his first hypothesis might be entirely wrong, for his observations could be explained equally well by assuming that his box was out in space far from any gravitating mass and that the apparent fall of a ball dropped from his hand was due, not to a downward acceleration of the ball, but to an upward acceleration of the box in which he is confined. In short, it is impossible to distinguish by dynamical experiments between a downward gravitational field and an upward acceleration of the observer's reference frame.

By optical experiments, however, the observer confined in the box might hope to determine whether he was actually at rest in a gravitational field or accelerated upwards in a field-free space. Suppose he should follow the course of a ray of light across his cage from the one side to the other. On pre-relativity notions, he would expect the beam of light to follow a straight path if he were at rest in a gravitational field, whereas, if the other alternative were the correct explanation of his dynamical experiments, he would find the beam of light to curve along the arc of a parabola. Einstein, however, assumes that by no means whatsoever can the observer in the box distinguish between the two alternatives. Since a ray of light would follow a curved path relative to an accelerated reference frame in a field-free space, so it would be deviated out of a straight line to an observer at rest in a gravitational field. Calculation shows that a ray of light grazing the limb of the sun should be deviated by the small but detectable amount of 1.74 seconds of arc. Imagine the astonishment of the scientific world when Eddington's photographs taken during the eclipse of May 29, 1919 confirmed this theoretical prediction—the first instance of an effect of gravity on light!

In our discussion of the observer in the box we have tacitly assumed the Euclidean space of pre-relativity concepts. As a matter of fact, Einstein finds it necessary to curve Minkowski's four-dimensional representative space in developing the general relativity theory. This curvature is appreciable only in the neighborhood of gravitating masses, space-time becoming practically flat at considerable distances from massive bodies. All physical laws are assumed to be expressed by tensor equations which have the same form no matter what reference system they are referred to, and material particles and light waves follow geodesics or curves of shortest length through the curved space-time. The idea of a geodesic is one that has been familiar to the navigator ever since he recognized that the earth is spherical in form. If we wish to lay out on a map the shortest course from New York to London we do not draw a straight line between the two points, but instead we connect them by the arc of a great circle. So long as the ship or airplane we are navigating is forced to follow the spherical surface of the earth, the arc of a great circle provides us with the shortest path between two points. In Einstein's theory bodies moving through a gravitational field tend to follow the most direct path: on account of the curvature of space-time produced by a gravitating center the shortest course is not a Euclidean straight line but a curve corresponding to the arc of a great circle on the surface of the earth.

In selecting a formula to express the law of gravitation Einstein chooses the simplest tensor equation which reduces to Newton's law as a first approximation. In only three minute details does Einstein's law lead to results differing measurably from Newton's law. In the first place the new law leads to a slow progression of the perihelion of a planetary orbit whereas Newton's law requires the orbit to remain unchanged in position. Only in the case of a somewhat elliptical orbit is this progression measurable, and the orbit of Mercury is the only one among those of the eight major planets which is not almost exactly circular. Here there has existed an unexplained anomaly in the motion of the perihelion which has been a puzzle to astronomers for half a century. The first triumph of Einstein's theory was the complete account which it gave of this discrepancy with Newton's law.

Secondly Einstein's theory predicts the deflection of a ray of light by a gravitational field in exactly the same amount as that of a material particle traveling with the same velocity, although double the deflection that would be suffered by a material particle subject to Newton's law. This deflection has been confirmed by the observations of Eddington already mentioned and even more precisely by more recent photographs of Campbell.

Finally Einstein's theory requires clocks to be slightly slowed down when placed near a gravitating mass. As an atom emitting radiation is an almost perfect clock, this means that lines in the solar spectrum should be displaced a very slight amount toward the red as compared with lines in the spectra of the same substances obtained in terrestrial laboratories. Attempts to verify this prediction of the theory have been complicated by the presence of spectral shifts due to other causes, such as pressure,

(Continued on page 38)

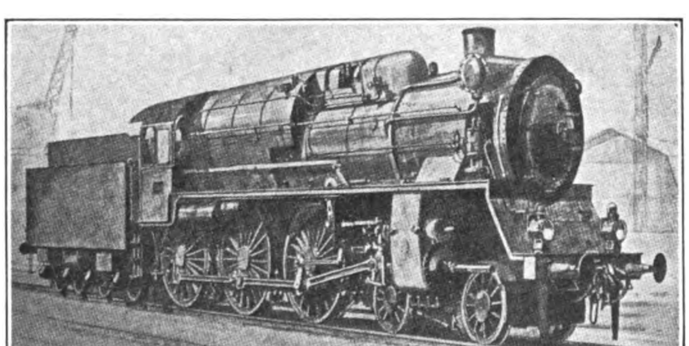
The Trend Toward High Steam Pressures

Use of High Steam Pressures Is of Great Importance in the Fields of Marine and Railroad Transportation and in Industry

By Henry Gardner

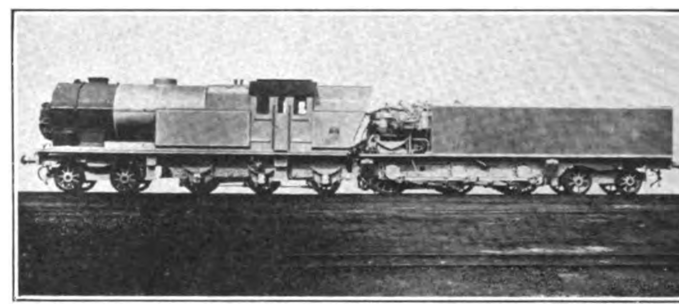
HIGH pressure steam generation is not new. In 1822 Jacob Perkins invented a coil type or continuous flow boiler which generated steam at 700 lb. per sq. in. with temperatures ranging from 700 to 800° F. A description of this boiler indicates that Perkins ran pressures, under test, up to 2000 lb. per sq. in. and higher. Later we had the DeLaval continuous flow type boiler for power plant service, patented in 1897. The pressure normally carried was 1700 lb. but pressures up to the critical were attempted, or 3200 lb. Working temperatures were about 600° F. The Talbot boiler in 1912, also of the continuous flow coil type used high pressure steam. For automobiles the well known White steam car (1904) contained a boiler of the continuous flow type operating at 300 lb. pressure. Also the Scott-Newcomb steam generator was introduced for automobile use about the same time. This boiler operated at pressures up to 600 lb. and temperatures of 800° F. Later the Doble steam bus was operated for some years and there is now a bus running successfully in Detroit which is equipped with a steam engine carrying 1250 lb. pressure at 800° F. temperature. Finally, a continuous flow coil type Benson boiler generating steam at 3200 lb. was erected by Siemens-Schuckert in their cable works plant, Berlin. This boiler has just gone into commercial operation. Another similar Benson plant is now under test in Charlottenburg University, Berlin.

The high pressure water tube type boiler was first considered for power plant service about six years ago and since then rapid strides have been made in the development of the art. This has been made possible by the introduction of new steel alloys capable of resisting very high pressures and temperatures. The first high pressure water tube boiler recorded was the Schmidt-



(*American Society of Mechanical Engineers*)
The First Schmidt High-Pressure Locomotive.

Hartman type, Kassel, Germany, operating between 700 and 900 lb. gage. This was built in 1922. A little later Borsig in Berlin developed a water tube drum type boiler operating at 60 atms. (860 lb. per sq. in.) and Bloomquist in Sweden brought out his revolving tube type "Atmos" boiler, installing two units in industrial plants with working steam pressures of 1500 lb. per sq. in. Loeffler of Berlin installed a water tube and drum type boiler in Austria, operating at 1750 lb. per sq. in. Later Schmidt installed several water tube drum type boilers with working pressures up to 880 lb. A Babcock & Wilcox cross marine type drum boiler was installed in Bradford, England, having a working pressure of 850 lb. The Langebrugge B&W boilers in Belgium are frequently referred to—they operate at 800 lb. pressure and about 850° F. temperature. Two B&W boilers of over 1000 lb. pressure were later installed on the continent. A Sterling boiler installed in Mannheim, Germany, was operated at 1400 lb. pressure and a Garbe boiler at Winterthur generated steam at 1425 lb.



(*American Society of Mechanical Engineers*)
Turbine Locomotive, Ljungström System, for L.M.S. Railways, England.

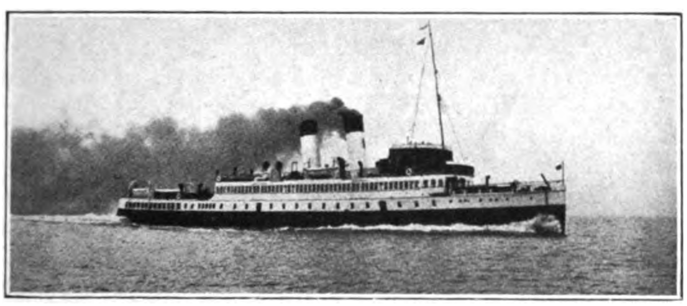
In this country, progress in high steam pressures has proceeded with more conservatism. A cross drum Babcock & Wilcox boiler was installed in Cincinnati with 615 lb. gage pressure; this was followed by the well known Crawford Ave. plant in Chicago with cross drum boilers operating at 615 lb. Later eight other similar installations were made of this type and pressure. The Edgar Thompson plant, Weymouth, Mass., installed B&W cross drum boilers with 1200 lb. working pressure. This was followed by the Lakeside Station, Milwaukee, with similar type boilers operating at 1250 lb. pressure. A little later Kansas City installed a Combustion Engineering boiler operating at 1400 lb. which is the highest pressure so far reported as commercially used in the United States. Pressures up to 1500 lb. have been reached under test conditions.

So far, except for a historical reference, the high pressure boilers mentioned have been used wholly for stationary power plant service. The transportation field is most promising for increasing boiler pressures and a brief resume of this development, to date, will be made. First, in marine service, the King George V, a Clyde River steamer was built in 1926 with Yarrow boilers having a working pressure of 550 lb. and a steam temperature of 750° F. Sir Charles Parsons, the designer, stated that if the Mauretania was similarly equipped the saving in fuel would amount to 40%. The Herreshoff and Talbot boilers were used principally in marine service; the latter carried pressures up to 600 lb. with correspondingly high temperatures. These boilers were not successful due to the undeveloped state of the art of automatic regulation and synchronization of fire, water and steam output. Had they been installed under the more favorable present day developments, including feed pumps and automatic control equipment, they might have proved commercially

successful. The Canadian Pacific has two liners having a working pressure of 350 lb. and the North German Lloyds' two new steamers of 46,000 tons, designed for 27 knots, are fitted with boilers of equally high or even higher pressures.

The Use of High Steam Pressures in Locomotives.

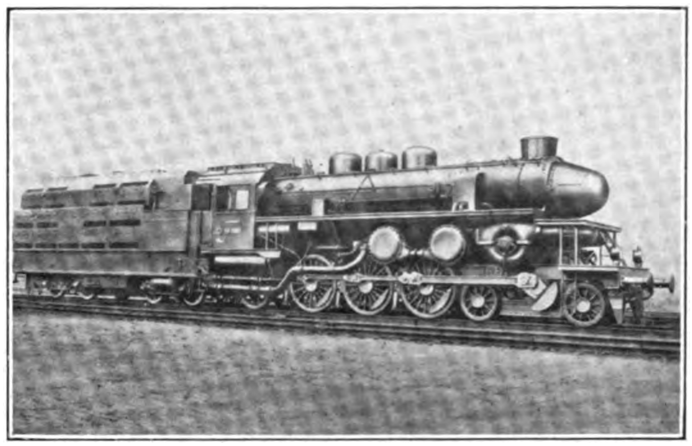
In railroad service steam pressures have advanced more rapidly in Europe than in America. Both European and American locomotives have up to recent years practically all been equipped with fire tube boilers having fire-boxes with large flat stayed surfaces. These boilers carried a maximum pressure of about 225 lb. per sq. in. The call for higher steam pressures led designers to turn to the water tube firebox as safer and more adaptable to higher stresses. The first locomotive boiler with a water tube fire-box was designed by the chief engineer of the Austrian State Railways, Herr Brotan, in 1901. This locomotive was used in freight service and the working steam pressure was 250 lb. Later there developed the Schmidt-Henschel locomotive boiler and the Loeffler locomotive boiler, both in Germany. The Schmidt-Henschel boiler was built under patents held by the Schmidt-Heissdampf Co., Kassel, Germany. This boiler and locomotive have been fully described in the American technical press. It is a combination water tube and drum type carrying maximum steam pressures of 1200 lb. Working steam pressure is 850 lb. The Loeffler locomotive is now under construction by the Berliner Machine Works for the German State Railways. This locomotive carries a water tube and drum type steam generating system operating at maximum pressure of 1470 lb. Both the Schmidt and Loeffler boilers are distinguished by the use of high pressure steam to make working steam of a lower pressure. By this plan the working steam generator is not exposed to the direct heat of the fire. Also distilled water is used thereby obviating corrosion and scale formation commonly found in non-condensing boiler systems. The Loeffler system is further characterized by a steam distributing pump which circulates high pressure steam between the generator, superheater and high pressure cylinders. A third high pressure locomotive system has been developed by the Swiss Locomotive & Machine Works, Winterthur. The water tube and drum type boiler carries a pressure of 850 lb. Tests of this locomotive have been reported as very satisfactory.



(*Marine Engineering*)
High Pressure Geared Turbine Steamer "King George V."

Another bold European project is the Benson turbine condensing locomotive to be built by J. A. Maffei of Munich. This locomotive will be similar in many respects to the well-known Maffei turbo-condensing locomotive built and operated in 1926 except that the new design will feature the Benson super-pressure continuous flow steam generating system at the critical pressure of 3200 lbs. The Benson system locomotive is designed to operate with working steam pressure of about 2500 lb. and about 750° F. temperature. It is expected that this locomotive will be under test by the German State Railways early in 1929.

In America, the first departure from the stereotyped fire tube locomotive boiler was a water tube boiler designed by Mr. J. E. Muhlfeld and installed on a locomotive operating on the Delaware & Hudson R. R. This locomotive, called the "Horatio Allen", has been fully described in Technical journals. The maximum steam pressure was 350 lb. Another similar engine called the "John B. Jervis", was built last year for the same company, maximum steam pressure 400 lb. The New York, New Haven & Hartford R. R. has installed a number of water tube McClennon boilers which operate at a working pressure of 265 lb. The well-known locomotive No. 60,000 recently built by the Baldwin Locomotive Works with water tube boiler carries a working pressure of 350 lb. The above locomotives are all giving excellent service in regular railroad operation. It is reported that the Pennsylvania Railroad will soon build a locomotive carrying a maximum steam pressure of 450 lb. but details are lacking at this time. Several types of railroad self-propelled



(*American Society of Mechanical Engineers*)
First 2000 H.P. Krupp-Zoelly Turbo Locomotive.

steam passenger cars have been developed in this country, and England and Germany have also produced steam driven cars but pressures were only nominal. The American cars carried pressures ranging around 500 lb. with correspondingly high temperatures. Steam power for buses has already been mentioned.

A few of the theoretical and practical advantages resulting from the use of high steam pressures and temperatures may be given. From a theoretical standpoint we find that figures obtained from a discussion of Rankine's cycle show a gain of over 50% in thermal efficiency for working steam pressure at 900 lb. over that attained at 200 lb. For locomotives, the increase in efficiency is measured by the difference in the heat content of the steam at admission to the cylinders and the heat content from the cylinders after expansion has occurred. This being true, if the initial pressure is increased through the application of additional heat, a relative increase in efficiency must result. Therefore, we may state that higher boiler pressures produce substantial increases in economy which are primarily due to steam temperature differences since all economies from the use of steam are reckoned primarily from heat units as a basis. As pressures rise the latent heat of vaporization, or non-productive heat, decreases; for example, the total heat content of a pound of steam at 500 lb. is virtually the same as for steam at 200 lb. pressure.

Advantages and Disadvantages.

A few practical advantages resulting from the use of high steam pressures and temperatures for power plants using water tube boilers may be given. Some of these statements are taken from a questionnaire sent out by Mr. Geo. Orrok, Consulting

Engineer, for information to be presented to the Mid-West Power Conference in Chicago this year.

Boiler troubles are no greater with high pressures than with ordinary 200 lb. pressures so long considered standard.

All operators agree that the installation of high pressures has been justified by results and its extension is recommended.

Replies show that both thermal and commercial economy have been realized from the use of high pressure steam and this is substantiated by repeat orders for similar installations.

The use of high pressure results in a considerable decrease in steam consumption and a lesser but appreciable decrease in coal consumption.

Some of the more important disadvantages should be mentioned; these are also quoted from Mr. Orrok's paper.

Feed pumps are a little more difficult to keep tight and in good working order.

Steam piping mains are more inclined to leak in joints, due to expansion and high pressures. This is easily rectified.

Gage glasses have had to be strengthened.

Economizer sections have given some trouble from leaking and overheating. Now corrected.

Hand hold gaskets have given some trouble but this can be easily eliminated.

Feed water regulators got out of order but were soon readjusted.

Some carrying over of finely powdered solids into turbines; depositing at higher pressures and temperatures and some scaling is apt to occur in nozzles and blades. This can be rectified by proper boiler water concentration. Some power plant operators report a slight oxidation of turbine blades and nozzles as well as the inside surfaces of castings exposed to the high pressure steam.

For locomotives equipped with water tube or continuous flow boilers, we have the following authenticated advantages:

Where space limitations and clearances exist, a greater tractive force and hauling capacity can be obtained by increasing the steam pressure. This is of great importance in increasing railroad operating efficiency and economy.

Locomotive boilers with high pressures may be made inherently lighter than the present fire tube boilers.

The circulation in water tube locomotive boilers is excellent and the time required for firing up is about two-thirds that for the standard fire tube boiler. It can also be washed out in a shorter time.

Records for five years show that one type of locomotive water tube boiler can be maintained at about one-half the cost of the conventional fire tube boiler.

After extended tests a saving of over 15% in coal consumption was shown for a locomotive water tube boiler over corresponding fire tube boiler. Also steam per indicated horse power decreased 6½% for the water tube boiler.

High pressure steam lends itself to a much more economical steam distribution and utilization. The modern high pressure boiler is equipped with superheaters, economizers, air preheaters and feed water heaters; all producing greater economy.

Summarizing the above advantages and disadvantages it may be stated emphatically that high pressure steam has passed the experimental stage and has come to stay. This is not only true for power plants but applies as well to locomotives, steamships and other steam power applications using either a drum water tube or a coil type continuous flow boiler. Mr. Orrok finally states: "that there appear to be no serious difficulties in the operation of plants using pressures ranging up to at least 2000 lb. per sq. in. Boiler companies state that they are also ready to guarantee service with temperatures up to 900° F."

Comparison of Turbine and Piston Steam Locomotives.

A good deal is being written about turbine locomotives—particularly on the continent. The turbo-locomotive does not necessarily constitute a high pressure steam unit but pressures up to 400 or 450 lb. are commonly proposed for turbine construction. As far as the turbine is concerned, pressures up to 800 or even 1000 lb. could be used practically in locomotive design. Escher Wyss & Co. of Zurich have recently designed a turbine for a steam pressure of 2560 lb. per sq. in. and 750° F. temperature for use with a Benson boiler. The turbine lends itself to higher pressures than the piston steam locomotive for several reasons, as follows:—

Low pressure steam and vacuum can be effectively used in turbines.

The turbine has no reciprocating parts and requires no lubrication; parts in contact with exhaust steam are free from oil, thereby ensuring clean condensing surfaces.

The turbine requires very little maintenance and its life is longer than the piston engine.

The steam turbine lends itself to flexibility demanded by load and speed variations.

The average saving in fuel consumption of a standard turbine locomotive has been given as 25% against a similar piston locomotive.

The total saving from turbine locomotive operation—fuel consumption, maintenance, interest and depreciation, etc., considered amounts to about 35%.

The turbine locomotive is adaptable for greater utilization, or long hours in continuous service.

Well informed European opinion is of the belief that many of these modern developments which have already been worked out commercially in stationary and marine practice can be successfully applied in locomotive design. They state that very high pressures of 900, 1500 lb. and even higher, with temperatures up to 850° F., used in conjunction with turbine drive and condensing features, can be made practical for railroad requirements and can be produced in units up to 5000 H.P. and predict a fuel saving up to 60% over the best modern piston locomotive performance. They also predict a thermal efficiency of 17 to 19% as compared with the present 7 or 8% of our best designed locomotives. The construction cost, as typified by the Ljungstrom, Krupp and Zoelly turbo-locomotives, is stated to be about 1.8% the cost of the present modern types. There is nothing in this cost to discourage the introduction of super-pressure locomotives since the savings effected are calculated to cancel the cost differential in three to four years.

It is not generally realized that the steam locomotive of today is not radically different from the original "Rocket" built by Stephenson 100 years ago. It has the same horizontal drum boiler, the same cylinders and a running gear and the same exhaust steam combustion draft. Motive power for transportation was steam propelled up to about the beginning of this century, when the trend toward internal combustion engine power was very

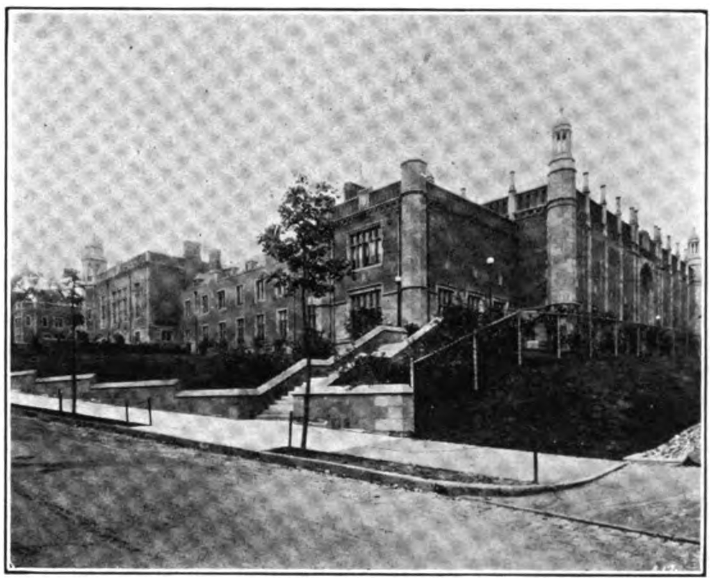
(Contiued on page 33)

Chemistry's Battle With Bacterial Diseases

Cooperative Research in the Study of Bacterial Organisms Makes Great Strides in Combatting Disease—The Scheme of Analysis Already Applied to Tubercle Bacilli Equally Successful in Other Fields

By Prof. Treat B. Johnson

THE program of research, which was instituted in the Sterling Chemistry Laboratory five years ago for the systematic study of the chemistry of tubercle bacilli, has finally developed into a cooperative research undertaking which promises to lead to results of the greatest importance in the fields of science covered by the divisions of Biochemistry and Bacteriology. Inaugurated originally under the auspices of the Research Committee of the National Tuberculosis Association for the study of a single bacterial organism—tubercle bacilli—the investigation has finally attained a significance and importance which has extended its scope far beyond the aims outlined in the original program of its organizers. As a result of the accomplishments of a well-organized group of workers trained in the technique of biochemistry and biology, the original program has been extended to embrace the study of any type of bacteria that can be grown artificially in the quantities required for chemical research. The scheme of analysis or biochemical assay already applied successfully to tubercle bacilli is applicable to any bacterial organism and opens up a new method for comparison of bacteria which was not known before the present investigation was started in the Sterling Chemistry Laboratory.



(*The Alumni Weekly*)

The Sterling Chemistry Laboratory.

Scope of the Research.

As a result of the preliminary work already accomplished, the major investigation has finally come to include various phases of chemical and biological technique including operations from the time of inoculation of synthetic media preceding growth of the organism in the manufacturing plant to the final biological experiments instituted to determine specificity of the respective chemical units separated from the original cell. The major investigation now functions so as to include the following subdivisions of a well-coordinated cooperative undertaking:

Three Phases of Current Research.

1. Government Cooperation: *Bacteriological control and standardization of cellular organisms and cultures employed in the research.* This feature of the investigation is entirely under the control of the Hygienic Laboratory of the United States Bureau of Public Health in Washington, D. C.

2. Commercial Production of Bacteria: *Growth and production of the bacteria required for research on a commercial scale.* In this work we have been fortunate in having the cooperation of two of our largest and best known commercial pharmaceutical houses, namely, Mulford and Company of Glenolden, Pennsylvania, and Parke, Davis and Company of Detroit, Michigan. The present investigation would never have been possible if these manufacturing resources had not been made available. Not only has this cooperation of manufacturers enabled us to develop our research program on a scale hitherto impossible, but the new data obtained as a result of the chemical and biological studies have contributed new knowledge of immediate practical value to the manufacturer and to an improvement in the quality of some of his products.

3. Chemical Analyses at Yale: *An exhaustive chemical analysis of the bacterial cells.* This work is carried on entirely in the Sterling Chemistry Laboratory where a group of trained chemists is devoting practically all of its time to this work. This chemical research which is the basic feature of the whole cooperative enterprise cannot be carried to successful completion without the assistance of chemists having a thorough knowledge of the chemistry of proteins, carbohydrates, fats and waxes, nucleic acids, amino acids, and related organic compounds. This work is of such an advanced character that only men or women with Ph.D. training are qualified to join the staff. The results which have already been obtained by the workers in the chemical unit have opened up entirely new lines of biological research which would never have been possible at this period except by some plan of cooperation comparable with the present undertaking.

Biological and Clinical Research.

Biological assay of the various fractions separated by the chemistry unit from the bacterial cell. This work is carried on by workers outside of the Sterling Laboratory. This feature of the research on bacteria is now conducted in various clinics in different universities and in research institutions including the Rockefeller Institute of Medical Research in New York City, and, also, in governmental and commercial laboratories. Many improvements in the manufacture of tuberculin, for example, have been made as a result of the new knowledge contributed by this joint investigation and it is very probable that, as new data is acquired

(*Continued on page 35*)

Traffic Regulated by Automatic Control

Yale Man Invents System Whereby the Flow of Automobiles at an Intersection Operates the Traffic Lights

ONE of the most serious economic problems which the modern city has to face today is that of traffic. The importance of the problem is greater than a casual glance would indicate. It has been estimated by the *New York Herald-Tribune* that New York is losing one million dollars per day in traffic delays. In many cases the economic production of a big city is checked and hindered by traffic congestion. The answer to the problem is, of course, improved regulation of traffic. Various means have been used to provide suitable direction. The first which comes to mind is the traffic officer. Here a man must be on duty constantly during the hours of heavy traffic to control the streams of automobiles. This system requires an enormous personnel where there are many intersections. The next step is a system of traffic lights operated from some point—possibly near the light, or better a centralized location from which a number of lights may be controlled. In reducing the necessary personnel we are confronted with the fact that we have reduced the flexibility of the system. We notice that regulation is necessary only at intersections, for it is a characteristic of traffic that it is a problem only when there are two sets of vehicles attempting to go in different directions. Conditions are not the same at any two intersections, and whereas the traffic officer could efficiently regulate traffic in his own region, the centrally controlled traffic light can not. At best it can only be an approximation of the mean of conditions at the various intersections with the result that all are ill-suited in varying degrees. The result could not but be inefficient.

A View Showing the Installation at Orange and Humphrey Streets in New Haven.

First Automatic Control Installed in New Haven.

It was with the idea in mind of decreasing the necessary personnel and at the same time providing the flexibility of individual control that the Electro-matic signal was devised. The inventor was Henry A. Haugh, Jr., a Yale man formerly connected with the Electrical Engineering Department. The signal is backed by the Stirlen Corporation—a company composed largely of Yale men. The first signal was installed and inaugurated early in April, 1928, at the intersection of Orange and Humphrey Streets in New Haven, Conn. Since that time they have been installed in Waterbury, Seymour, Branford and other cities in Connecticut as well as in Providence and on the DuPont Highway and the New Castle-Newport road in Delaware.

The Automatic Traffic control is not a new traffic light, but it is rather a device which may be attached to existing lights to make them fully automatic and independent of manual adjustment or switching. The essential components are contacts set in the pavement on the right-hand side of the street which connect to a control box. The control box in turn connects with the traffic light. The contacts consist of metal plates covered with rubber and set flush with the pavement which operate by pressure rather than by movement. This is a necessary feature because it allows effective operation even under ice or snow, either of which might impede the movement of the strips. The switches are adjusted so that they trip when an automobile passes over them, thus making the circuit through the control box and operating its mechanism. The arrangement of contacts and control box are shown in the diagram.

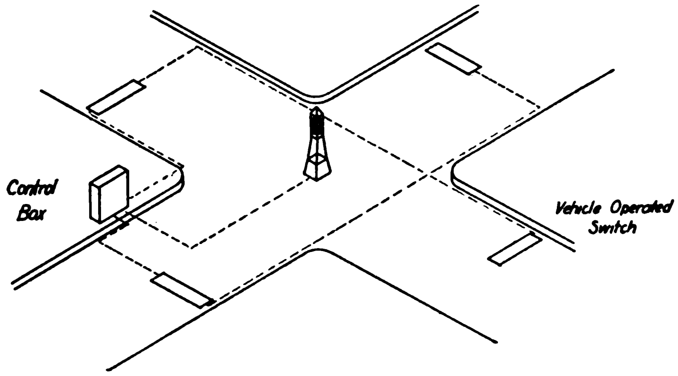


Diagram Showing Location of Contacts and Control Box.

The method of operation is such that it takes care of the different situations arising at an intersection with remarkable facility. If a car approaches an intersection where the lights are set against it, and no cars are approaching on the cross street, the light will change and allow the car to pass. If other cars are following, it will allow them to pass also, and then return to its original position. Similarly a car approaching an intersection where the lights are set for it will be allowed to pass unless a car on the cross street has reached the intersection first. This prevents the delay and aggravation of having the lights change against you at a corner when no cars are using the cross street.

No Unnecessary Delays When Traffic Is Light.

Cars on one street are never compelled to wait unless there are actually cars passing on the intersecting street. The light will change and allow them to pass. If there happens to be a steady stream of traffic on the other street, the approaching cars are made to wait. If, however, a break occurs in the stream the light will change to allow the other cars to pass and then return to its original position favoring the busy street. In this feature

(Continued on page 33)

New Electric Furnace For Steel Treament

Revolutionary Change in Hardening of High Speed Steel Brought About by the Development of a New Type of Electric Furnace

By Prof. Wesley B. Hall

A NEW type of electric furnace for hardening high speed steel has been developed by Professor W. B. Hall of the Electrical Engineering Department and the Bellis Heat Treating Company of Branford, the work being done at the Dunham Laboratory of Electrical Engineering and at the plant of the Company in Branford. This furnace is such a radical departure from previous types that it has excited considerable interest and may have an influence on the tool hardening industry.

Use of High Speed Steel.

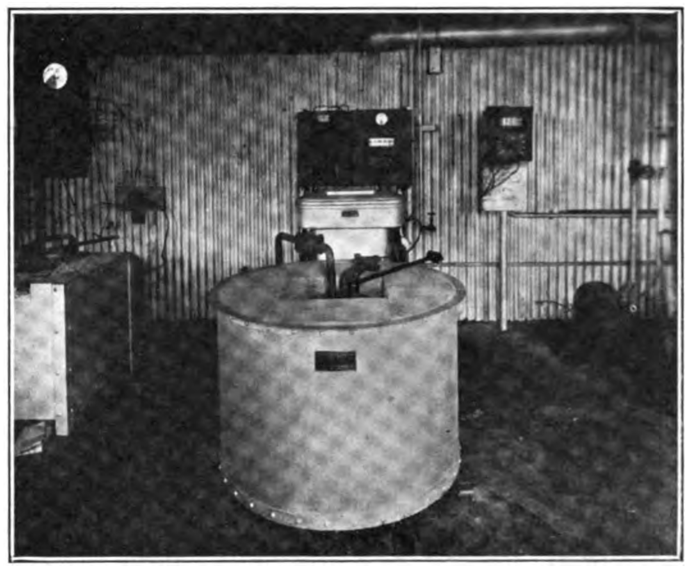
To describe what this furnace accomplishes it may be well to give a short description of the use of high speed steel in industry. High speed steel was introduced into machine shop practice a few years ago for use as a cutting tool on lathes, planers, etc. It is an alloy of tungsten, chromium, and vanadium with steel, a typical analysis being tungsten 18%, chromium 4%, vanadium 1%, carbon 0.65%, and the rest iron. It has a very long life as a cutting tool and retains its cutting efficiency when used at such a rate as to cause a dull red heat. It is now universally used for all machine tool work, and is being rapidly adopted for use in finished tools, such as drills, milling cutters, dies, taps, files,

Three Pot Furnaces in Operation.

hacksaws, punches. The use of this steel has however been somewhat retarded by the difficulty encountered in hardening it.

Difficulties Encountered in Hardening Steel.

To harden this steel it must be heated to 2300 degrees Fahrenheit, then cooled suddenly or "quenched" to 1100 degrees Fahrenheit, then quenched to room temperature. 2300 degrees is an extremely high temperature. Oven type oil and gas furnaces have been used for this operation, but their life was short, the lining of the oven requiring frequent renewal. They were noisy and heated their surroundings to such an extent that they were uncomfortable to work with. During the time a piece of steel was coming up to temperature, it would oxidize in the furnace, which pitted the surface and covered it with "scale". This spoiled the cutting edge on finished tools, and limited these furnaces to the hardening of tools which could be ground sharp after hardening. Special furnaces have been built which exclude air and heat the tools in an atmosphere of some inert gas, but the difficulties attending this are obvious, and the hot steel is exposed to air upon removal from the furnace before quenching. Electric heating would have increased the furnace life and made



Single Pot Furnace with Transformer and Automatic Temperature Controller.

the working conditions more endurable, but the temperature required is above the melting point of the nickel-chromium resistance units used for electric furnaces. Experiments are now being carried on in various places with non-metallic resistance units in an effort to produce a satisfactory oven type electric furnace.

A New Way of Heating Steel.

Because of these difficulties, Mr. A. E. Bellis of Branford developed in 1920 a salt which should be molten at 2300 degrees F. into which the steel could be dipped to heat it. This salt was placed in a steel pot and heated by a gas or oil flame on the outside of the pot. The steel to be hardened was dipped in the molten salt. One advantage of this method over the oven type furnace was that the steel absorbed heat from the molten salt much faster than from air, so that it reached the furnace temperature in a minute instead of requiring ten or fifteen minutes to heat up. Also the molten salt protected the steel from the air, and thereby prevented oxidation. A film of the molten salt adhered to the work when it was removed and continued this protection during the subsequent cooling process. It was necessary to make a salt that would be stable at this high temperature, and which would not attack the steel in any way, and which would not itself oxidize. This salt fulfilled all these require-

ments. However, the use of this salt was still hampered by the effect of the high temperature and the flame on the pot. The pot life was short, in some cases renewal being necessary nearly every day. Electric heating was just as impracticable as for the oven type furnaces.

This is the situation which brought about the new electric salt bath furnace. In this new furnace, the resistance units for heating were eliminated by passing electric current through the resistance of the molten salt bath itself. This was accomplished by immersing a metal rod into the bath and passing current from it to the pot wall. The composition of the salt was changed slightly to make its electrical resistance more suitable. The resultant bath requires high current at a relatively low voltage, which must be supplied from a transformer which becomes part of the furnace equipment.

This method of heating at once eliminates the necessity for the pot and its surroundings being hotter than the bath. The heat is generated right in the salt, where it is desired, and the temperature gradient is downhill all the way from the salt out through the pot and its support. Also, the pot can be mounted in a heat insulating support with no limit to its thickness, which means great economy in power consumption and protects the pot on the outside from the atmosphere so that, coupled with the lower pot temperature for a given bath temperature, the life of the pot is prolonged almost indefinitely. This method achieves almost ultimate simplicity, for there is no apparatus at all around the pot—no burners and combustion chamber, no heating elements, nothing but the bare metal pot set in a heat insulating support, with an electrode dipping into the bath.

Since the heat is not forced to flow through the pot wall into the bath, but is generated right in the bath itself, there is no limit to the amount of heat which can be supplied. Power can be put in at a rate to permit production as fast as the pieces can absorb heat from the bath, without any overheating of the furnace structure.

The pots illustrated are small ones for hardening of small tools, such as drills, taps and dies. They are eight inches in diameter by fourteen inches deep. The electrode is one inch in diameter, and is immersed about ten inches. The transformer supplies about 1800 amperes at eleven volts, drawing 90 amperes from the 220 volt supply circuit. There is automatic control, of course, turning the power off and on so as to hold the temperature constant at the desired value.

Three pots are generally used as a unit, as shown in the second illustration. The first pot is kept at 1800 degrees F. for gradually raising the temperature of the work from cold; the second pot is kept at 2300 degrees F., and the work is taken from the first pot into this to heat it to the required hardening temperature; the third pot is kept at 1100 degrees F., and the work is taken from the high temperature pot and quenched suddenly to this temperature. After remaining in the third bath a short time, the work is taken out and quenched in oil or some other unheated medium.

Resistance heaters using nickel-chromium resistors might be used for the first and third pots, where the temperature is not so excessive, but it has been found convenient to heat all of these by the same method, using a separate transformer and automatic controller for each pot.

The third or quench pot is necessary for metallurgical reasons to properly harden the steel. A special salt is used in it, differing from the salt used in the high temperature pot, because the high temperature salt freezes at about 1700 degrees F. which is above the temperature required for the quench.

The first or preheat pot is not necessary from a metallurgical standpoint, but is used to heat the work slowly, since if the cold work were immersed directly in the high temperature pot it would perhaps crack or warp due to the sudden heating of the outside while the center was still cold. The preheat pot uses the same salt as the high heat pot, operating just above the melting point of the salt. When cold work is immersed in it, a thick layer of the salt freezes around the work and protects it from the bath, permitting it to heat up slowly. When the bath temperature is reached, the layer melts off and the work is ready for the high temperature pot.

Advantages of the New Method.

This method of hardening offers complete protection to the work against oxidation. While in the bath, air is excluded. The bath itself is completely neutral to the work. When removed from the bath for transfer to the next pot a film of molten salt adheres to the work, protecting it against the atmosphere during transit. The result is that there is no oxidation or scaling of any kind. The work may be completely finished and sharpened before hardening, and will come out of the process with exactly the same physical shape and surface as it had on entering.

Difficulty has been experienced with oxidation of the pot and the electrode. This difficulty has been largely overcome by the selection and development of proper materials for these, and the work on them is being continued.

The heating efficiency is very high, over 90% of the input power being developed as heat in the bath itself. The fact that the heat insulation starts right at the pot wall and that there is no limit to the thickness of the insulation keeps the heat loss down to a low value. As a result of this the power consumption is small. Electric heating usually costs more for power than the fuel cost for combustion heating of the equivalent fuel furnace. But the cost for the power consumed by these pots has been found in actual use with power costing 1 cent per Kilowatt Hr. to be less than the fuel cost for the same pots built into oil fired furnaces.

Working conditions around these furnaces are excellent. The heat lost into the surroundings is so little that the operator remains cool and comfortable. There is no exhaust gas to dispose of and guard against.

These furnaces are believed to be the first industrially successful electric furnaces for hardening high speed steel. They have been installed in a number of industrial plants and used there in intensive continuous production for more than six months with gratifying success. They were exhibited at the National Metals Exposition held in conjunction with the Annual Convention of the American Society for Steel Treating at Philadelphia in October. It is believed that they offer a real advance in the art of heat treating high speed steel.

GEOLOGY NOTES

Professor Knopf spent the summer doing field work for the U. S. Geological Survey in Plumas County, California.

Professor Dunbar was in Nebraska and Illinois during August and September making a special study of the fossils in geological formations of carboniferous age.

Professor Longwell completed field studies in southern Nevada in which he has been engaged for the last six years. On the return journey to New Haven he stopped in southern New Mexico to visit a locality from which Peabody Museum obtained last winter a fine specimen of an extinct ground sloth.

Professor Flint is progressing with his study of glacial features in Connecticut. His work during the last two years has thrown light on the last stages of the Ice Age in New England.

The Undergraduate Is Learning to Fly

Aviation Has Become a Prominent Feature of University Activity—Yale Holds the First Intercollegiate Aviation Conference

By Nickolaus L. Engelhardt, Jr.

MOST of the larger universities have found themselves faced with a new problem in extra-curriculum activity. With the tremendous strides which aviation has taken in the last three years, college men have been attracted in large numbers to this new field. In many colleges the students are studying aeronautics from the theoretical standpoint in an endeavor to find a place for themselves in this new field. But there is still one great part of aviation which the colleges cannot hope to handle in the curriculum, namely, the art of flying. But regardless of this fact college men will fly. They are young, ambitious, seeking a new adventure, and they find this new life in flying. It is a fascinating activity. And furthermore, it is very much worth while from an educational standpoint because it offers to the student a thorough insight to the problems of air commerce. The sporting element of flying is merely an adjunct to the consideration of aviation as a business. It is to the young men that the nation turns for the advancement of its transportation system and it is to the young men that the nation turns for military aerial protection in time of need.

Since the colleges cannot in themselves support flying, students in over twenty-five large universities have organized flying clubs. These clubs play a definite part in aeronautics by stimulating and assisting college men in flying. They form a highly desirable extra-curriculum activity not only from the standpoint of permitting a wholesome outdoor activity but because of the educational value.

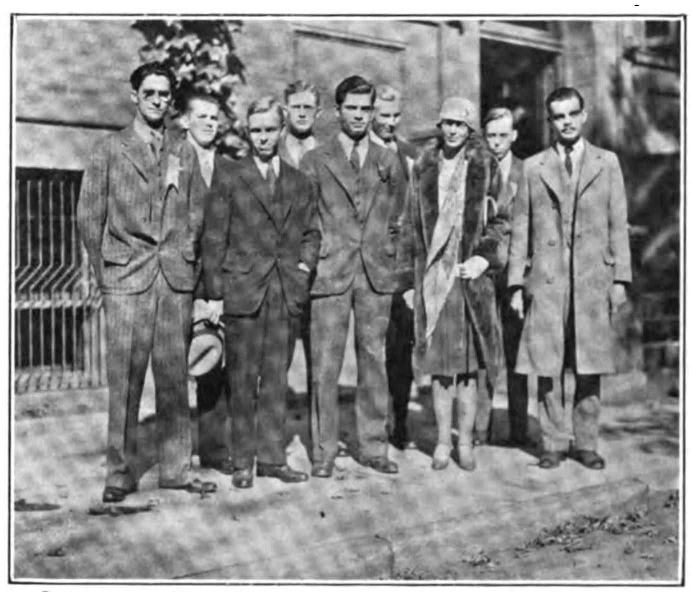
Organized Aviation at Yale.

The Yale Aeronautical Society is just that type of organization, and in addition projects and supports other aeronautical activities including research, experimenting, ground school, and

The Yale Pilots in 1927.

intercollegiate activity. This Society was organized late in 1926.

Since its organization the Society has managed to develop a few very vital points of aeronautical importance in and around the university. In the spring of 1927 a very definite recognition of its existence was given by the local aeronautical industry and cooperation was readily secured in several problems, principally in the control of student flying. In the fall of 1927 the Society recognized the importance of an airport in New Haven and proceeded to conduct a very exhaustive study of the situation. The cooperation of the city fathers was sought, and, as a result, an airport will be constructed here in a very short time.



Presidents of the Aeronautical Societies Represented at the Conference with Miss Amelia Earhart During the Meeting in New Haven.

Flying continued at a rapid pace and in the spring of 1928 the University authorities began to realize the importance of this new activity by recognizing the Society as an undergraduate club. However, in its recognition it was realized that flying itself could not be a regular part of its activity because of the responsibility it might involve on the University. When we stop to figure the accidents which have occurred in Varsity football in the last two years as opposed to a record of no accidents in undergraduate flying in the last two years, we might readily assume that the attitude of the authorities will be only temporary. The members of the Society have flown over six hundred hours since its formation and the total flying time of the members amounts to well over one thousand hours which represents about one hundred thousand miles flown. Last year there were six pilots in the Society and this year an entirely new group of seven pilots are in the organization. Four planes are owned by individual members with promises of at least two more before the close of the college year. Many men are flying continually in order to obtain their licenses.

In the spring of 1928, Grover Loening, president of the Loening Aeronautical Engineering Corporation, offered prizes amounting to $5000 to clubs participating in an Intercollegiate Air Race. The Yale Society could not enter this race as a Society and, as a result, Yale could not be represented. When this was realized

the Society carefully analyzed the situation of intercollegiate activity and after much consideration and on the advice of members of the alumni, it was decided that such an activity was out of place at the present stage of aviation for two reasons. First, the high cost of instruction prohibited college men from obtaining proper flying time, and, second, the race as a race was not safe in present types of planes.

The First Intercollegiate Aviation Conference.

With this matter decided, it was felt that Yale must find a new means for entering into the intercollegiate field. The solution was found in the calling of the first Intercollegiate Aviation Conference at Yale on October 19-20th, 1928. The Conference, although still too much in the present to form definite opinions, solved many problems. It brought together the clubs of eleven eastern universities, including Illinois, Detroit, Carnegie, Cornell, Pennsylvania University, Harvard, Massachusetts Institute of Technology, New York University, Northeastern, and Brown. The Air Race was called off, and in its place a competition was established which is to be based on the greatest number of flying hours per man per club. This competition has already stirred considerable excitement among the Yale undergraduates primarily because the Conference brought out very emphatically that the Harvard Flying Club was our chief rival. Here is a real competition between the universities and especially between Harvard and Yale.

A Flying Exhibition at Yale Field in 1911.

Student Flying Agency Needed.

To run this flying business under such pressure brings out two very important factors, namely, safety and economy. Safety can only come about by thorough control of the flying students by the club. This is being done and the present record of the Yale Society indicates that the men realize that safety is paramount. Proper ships and adequate inspection of ships are essential but are expensive. Flying instruction under commercial companies is not only expensive but totally unsatisfactory. What Yale needs is a Student Flying Agency to own, operate, and maintain planes, instructors, and mechanics.

The students alone cannot be expected to finance the initial burden of such an agency, yet by careful figuring it is realized that such an agency, if properly financed and properly handled, could reduce flying costs to at least one-half the commercial rates and still be able to build up a surplus. Such an enterprise must be assisted in its endeavors by alumni interested in the promotion of this new field of activity. Several of the members of the Aeronautical Society have gone ahead with plans for the incorporation of a Student Flying Agency, separate and apart from both the Aeronautical Society and the University, yet with the sole purpose in mind of supplying instruction to the students at extremely reduced rates. The agency is to be owned and operated by Yale men in the interests of Yale flyers. It is not a commercial undertaking, yet returns from the investment are not altogether impossible to be realized.

By means of this agency it is believed that the Society members can build up sufficient flying hours to trim Harvard in the competition, yet without the agency it is feared that Harvard will win the laurels. Remember, that in 1919 Yale won first place in the Intercollegiate Air Meet at Mitchel Field, Long Island, and if Yale is to hold this position it must win this new competition.

OUR CONTRIBUTORS

Professor Hudson B. Hastings, whose article on "Training the Business Executive" appears in this issue, is Chairman of the Department of Industrial Engineering in the Sheffield Scientific School. He graduated from Massachusetts Institute of Technology with the degree of B.S. in 1907 and received an honorary M.A. degree from Yale in 1923. He is a member of Sigma Xi and the Yale Engineering Association.

Treat Baldwin Johnson, '98 S., who discusses the progress of chemistry in combatting bacterial diseases, is Professor of Organic Chemistry and has been a trustee of the Sheffield Scientific School since 1920. Professor Johnson received his Ph.D. from Yale in 1901 and has been connected with the Chemistry Department ever since his graduation.

Leigh Page, who writes on Relativity in this issue, is Professor of Mathematical Physics in the Sheffield Scientific School. He received his Ph.B. with the Class of 1904 S. and was given a Ph.D. in 1913. He is now President of the Yale Chapter of Sigma Xi and has written an essay on the "Theory of Gravitation".

Wesley B. Hall, '16 S., is an Assistant Professor of Electrical Engineering. In November 1927, while connected with the Connecticut Company for the installation of a large mercury rectifier, he spoke before the Conference on Industrial Electrical Heat Treatment of Metals on "How Electricity Heats and its Control". In this issue he discusses electrical furnaces.

Arthur Henry Smith, who writes on Nutrition, graduated from Ohio State University with the degree of B.S. in 1915 and was given an M. S. by the same university in 1916. He received a Ph.D. from Yale in 1920. At present he is Assistant Professor of Physiological Chemistry in the Sheffield Scientific School.

Henry Gardner is a graduate of the Massachusetts Institute of Technology, having been given the degree of M.E. in 1896. At the time of writing the article on high steam pressures which appears in this issue, he was Engineer for the Steamotor Company of Chicago.

Nickolaus L. Englehardt, 1929 S., is Chairman of the New Haven Airport Survey, President of the Yale Aeronautical Society, and Secretary of the New Haven Chapter of the N.A.A. He is the author of an article on "Standard and Score Card for Municipal Airports" which appeared in "Airway Age". In this issue he writes on the Collegiate Aeronautical Convention.

Some Current Points of View in Nutrition

Physiological Chemistry Proves Man Does Not Live by Bread Alone—New Dietary Principles Bear Fruit in Preventive Medicine

By Prof. Arthur H. Smith

THIS is the age of the popularization of science. Not only does one encounter in the newspapers the accounts of research described with typical newspaper accuracy in such matters but there have appeared from time to time in the better magazines serious attempts to induct the readers into the purposes, methods and achievements of various branches of scientific interest. Indeed, entire books have recently been devoted to the tales of hunters and fighters who used microscopes and test tubes instead of guns and sabers.

In this campaign of popularization the science of nutrition has been especially singled out for attention probably because people always like to discuss the food they eat and hope perennially to change their physique or general health by simple dietary readjustments according to some dogmatic rule, but most certainly because of the tremendous stimulus given to popular inquiry into the principles of nutrition by the temporary exigencies of the late war. Whereas prior to 1917, the layman was content to follow the dietary proscriptions of the physician, at the end of the war calories, vitamins and proteins had found a place not only in the vocabulary but also in the thought of the nation. This popular interest, often enthusiastic if somewhat uncritical, has, in turn, given rise to a revivified conception of nutrition as one of the fruitful fields of preventive medicine.

Protein in Nutrition.

Nutrition has been called the child of physiology and chemistry and, as the offspring of two vigorous parents, has grown with impressive rapidity. While it is difficult to attribute to any one time or person the beginning of this science, certainly the classical studies of Voit and his school in Munich gave great impetus to the advance of certain phases of nutrition. This group early developed an interest in the metabolism of nitrogen in the body, thus showing, in a sense, the persistent influence of the great chemist Liebig. After following the various transformations of protein in the organism the very practical question of the level of protein intake presented itself. How much of this essential food stuff should be eaten per day in order to maintain the optimal state of physiological well-being? Based partly on statistical evidence, the conclusion was reached that the total daily allowance of dietary protein for a normal adult should be about 150 grams. This so-called Voit standard remained as the accepted ideal in nutrition until early in the present century when there developed a reaction, led by Chittenden[1]. On the basis of extensive experiments carried out at Yale, he concluded that physiological economy would be best served when the protein of the daily ration was reduced to one third that recommended by the German school. These conclusions did not pass unchallenged and for some years there was maintained the lively discussion as to the ideal quantity of protein required in the ration for normal nutrition. The importance of the quantity aspect of dietary protein is also illustrated by the then current practice of evaluating rations on the basis of the "nutritive ratio" which means the relation of digestible protein to the digestible fat and carbohydrate of the diet.

[1] Former Dean of the Sheffield Scientific School.

Meanwhile the problem of protein in nutrition was being attacked somewhat differently. It had been found that these nitrogenous compounds could be decomposed by boiling with acids or with alkalies and that there was thus always obtained the same hydrolysis products, namely, a certain relatively few alpha amino acids and that most proteins studied yielded, with this treatment, the same amino acids. A few proteins, however, were incomplete in that the hydrolysis mixture obtained from them failed to contain one or more of the usual amino acids. Biological studies correlated with these strictly chemical investigations were carried out and it was observed that proteins which failed to yield certain amino acids on hydrolysis in the laboratory likewise failed to adequately nourish experimental animals when in an otherwise satisfactory ration. Thus gliadin, a protein from wheat flour, contains so little of the amino acid lysine that growth of young animals is impossible and zein, from corn, will not even serve to maintain an animal because of the low content of lysine and tryptophane. On the basis of such correlated biological and chemical studies a few amino acids have been designated as "essential" because, when the ration is otherwise adequate, the organism cannot synthesize these compounds but must obtain them from dietary protein. Up to the present time lysine, tryptophane, cystine and histidine have been found to be indispensible for normal growth and maintenance. The discovery of the physiological importance of amino acids and especially of a certain few amino acids has changed the attitude of the student of nutrition towards proteins. The question of How Much has given way to What Kind; we no longer are interested only in the quantity but are recognizing the importance of the quality of the proteins in the ration as well.

The Vitamins.

Down to the early years of the present century it was assumed that a perfect diet must contain protein, fat, carbohydrate, mineral salts and water. When, for experimental purposes, it became desirable to simplify the ration to the mere essentials, efforts were made to feed animals on diets consisting of more or less highly purified food stuffs. But such attempts rarely met with success. Indeed, the more highly purified were the constituents of the ration the less satisfactory were they in maintaining the experimental animals. On the other hand, animals could easily be reared and maintained on rations derived from natural sources. Such experiences early emphasized the probability that, in natural foods there occurred dietary factors which were absent in the more highly purified foods and that these factors were essential to the continued health, maintenance and growth of the experimental animals. These indispensible food factors have been called vitamins and the postulate of their existence rests on a firm experimental basis. They can be demonstrated in fruits, vegetables, green leaves, milk, butter, eggs and in certain organs such as liver and kidneys, and highly concentrated preparations of marked potency have been made from these natural foods. Through a careful study of the effects obtained when the vitamins have been withheld from the ration and the subsequent cure when the missing factor is added, they have been roughly

classified. Too much reliance can not be placed on the apparent specificity of these food factors, however. The following table summarizes the present state of our knowledge of the vitamins and their distribution.

Name	*Disease Cured*	*Rich Sources*
Vitamin A	Ophthalmia, gland abscesses, urolithiasis, pulmonary infections	Butter, cod liver oil, spinach, egg yolk, carrots.
Vitamin B (B_1)	Polyneuritis	Yeast, grain embryo, unpolished rice.
Vitamin C	Scurvy	Lemon and orange juice, raw cabbage, tomato.
Vitamin D	Rickets	Cod liver oil, egg yolk.
Vitamin E	Sterility	Wheat germ, lettuce.
Vitamin F (B_2)	Pallagra-like lesions	Yeast, green leaves.

One of the striking characteristics of the accessory food factors is the exceedingly small quantity required to maintain an animal in health or to cure the condition resulting from the deprivation of the given vitamin. Two or three milligrams per day of good cod liver oil will satisfy the needs of a rat for the fat soluble vitamins, and a daily dose of three cc. of tomato juice will protect a guinea pig from scurvy when given an otherwise scurvy-producing ration. Our information of the chemical nature of these food factors is, unfortunately, not at all commensurate with the knowledge of their physiological properties. The most potent so-called vitamin concentrates are highly impure preparations in the chemical sense. Moreover, the chemical lability of these substances is such that ordinary laboratory manipulation renders them inactive. The discovery of the vitamins and their partial characterization has served to emphasize the importance in the diet of natural foods such as fruits and vegetables and the desirability of not cooking everything one eats.

Light and Nutritional Physiology.

Man instinctively seeks light, physical as well as intellectual. The traditional value of sunlight for the health of children and for the healing of fractures is familiar. One of the contributions of nutrition during the present decade has been the piecing together, link by link of the chain of evidence which explains, in part, the beneficent effect of sunlight. The present interest in light developed from an exhaustive study of the disease called rickets, long known but until recently, poorly understood. This is a condition of faulty mineral metabolism in which the most obvious indication is the failure of normal calcification in the long bones of the legs and arms, the ribs and certain of the skull bones. Cod liver oil is a preventitive and cure, due to its richness in vitamin D. Direct sunlight will also bring about a normal calcification of the ricketic bones but light which has passed through a glass window has no curative action. It has been shown that the short rays of the spectrum—the ultra violet rays—are filtered out by glass while fused quartz permits these rays to pass through. A mercury vapor arc in a quartz vessel provides a potent source of the ultra violet or vital rays and has been demonstrated to be more powerful than sunlight in curing rickets.

In an effort to explain this curative action of ultra violet light various substances were subjected to irradiation by light from a mercury vapor lamp. It was found that antiricketic potency can actually be conferred on a variety of foods in this way. Cotton seed oil, olive oil, various cereals and lettuce can be rendered active. A fractionation of cod liver oil, which is naturally antiricketic, and of cotton seed oil after irradiation, brought out the fact that the rickets-curing properties of these oils resides in the nonsaponifiable, ether soluble fraction and the common constituent of these natural oils answering to that description is cholesterol. Crystallized cholesterol from other sources, brain, for instance, when irradiated with light of short wave length also becomes active as an antiricketic agent. Concomitant with the development of the curative power there occurs a change in the absorption spectrum of cholesterol. Painstaking efforts to purify active cholesterol have resulted in the separation from it of a very small amount of "contaminant," ergosterol, which seems to be the active agent in irradiated natural foods. It is exceedingly powerful in its antiricketic activity, as little as 0.000005 milligram of irradiated ergosterol being sufficient to initiate calcification in the bones of a ricketic rat. The skin is relatively rich in cholesterol and the efficacy of sunlight in curing rickets is doubtless conditioned by the ability of the accompanying ergosterol to be activated by the short waves of light. Irradiated ergosterol dissolved in olive oil is now a valuable therapeutic agent but the proper dosage must be used if an overmobilization of bone-building salts and the consequent deleterious effects are to be avoided. These recent observations promise to be of great practical value and serve to bring out the nutritive importance of quantities of material too small to be comprehended. They likewise lend force to the ancient dictum that man shall not live by bread alone.

Nutrition and Inorganic Salts.

Approximately five per cent of the body consists of mineral matter. The contraction of muscles, conduction in nerves, the growth of bone, and the movement of fluid in the tissues depend on the presence of inorganic salts. When a ration is largely devoid of salts, increase in body weight soon ceases in a young animal, but recent studies have shown that there is a persistent tendency for the long bones to continue to grow in length at the expense of thickness. The result is a distortion of the skeleton and a peculiar gauntness in appearance. Not only the quantity but also the quality of the ash in the diet is important. The ash of the bones consists largely of calcium phosphate and it is obvious that, for the growing organism, both calcium and phosphorus are necessary. However, optimum bone growth depends on the ratio of these two elements present in the food; the ideal proportion being close to that of milk, namely $\frac{Ca}{P} = 1.3$. In addition to the commonly recognized essential inorganic elements, it has been shown that mere traces of certain others are necessary for various body functions. Thus a few milligrams of iodine promote cell activity through its action in the metabolism of the thyroid gland. Again, iron seems to be essential to blood formation and, in certain conditions, is far more effective in the presence of a trace of copper. Likewise minute quantities of zinc seem to promote normal growth and reproduction in experimental animals. As further delicacy and accuracy in micromethods are attained, physiological requirements for other more or less uncommon inorganic elements will doubtless be demonstrated.

In the foregoing paragraphs there have been presented some of the current trends of thought based on recent investigation in nutrition. The question has been asked frequently whether the human race has not, by its very existence, justified a more or less instinctive selection of foods such as is still practiced among savage peoples. Experimental animals in confinement when given a choice between several inadequate rations, will choose from each so that the combined selection represents a dietetically adequate food. Modern living conditions and training, however, make an instinctive selection of food by human beings a hazardous undertaking. The exigencies of urban life present one difficulty. Much of our most commonly used food

(Continued on page 40)

The New Medical School Laboratories

The Completion of the Addition to the Anthony N. Brady Medical Laboratories Increases Medical School Facilities

THE latest of the additions to the equipment of the School of Medicine, which consists of an addition to the Anthony N. Brady Memorial Laboratory, is practically completed. Many of the facilities have been available since the beginning of the academic year. Construction was begun in June, 1927. The building was designed by H. C. Pelton and constructed by Hegeman-Harris. The cost of the building is estimated to be $1,250,000 and has been entirely met by the General Education Board. It is in itself larger than the Sterling Hall of Medicine, and together with the original wing of the Anthony N. Brady Laboratory, it has a capacity of two million cubic feet.

The new building is located at the corner of Cedar Street and Congress Avenue, New Haven. Connection is afforded with the Administration Building of the New Haven Hospital by means of a covered archway. The archway allows access to the inner court of the building, which will ultimately be the point of maximum traffic for delivery to the hospital.

The ground floor of the original building is used as an entrance floor for students and workers in the new building, and is given over to lockers and rest rooms. The ground floors of the new wings are devoted to technical procedures essential for the work of the laboratory. These include surgical pathology activities and a large well-equipped photographic establishment, capable of conducting every type of photography necessary for scientific work. The first floor of Brady Laboratory is occupied by the Yale School of Nursing for administrative offices and class rooms.

The first floor of each wing and the second floor of the Congress Avenue wing, are devoted to Pathology. The rapid expansion of the work of this department and the co-operation with the local community and the hospitals and physicians throughout Connecticut have made necessary increased facilities than have formerly been available. The entire second floor of the Cedar Street wing is occupied by the Department of Public Health. This department, under the direction of Professor C.-E. A. Winslow, has become well known because of its activities in the State and in national and international health affairs.

The University's work in Bacteriology occupies the entire third floor of the building. Professor George H. Smith is located here, as is also Professor Leo F. Rettger, who has done the important work on the Bacillus Acidolphus. The studies in Bacteriology associated with Medicine and with agriculture and animal diseases are located in this section. The location gives more spacious quarters and an opportunity to expand and increase the work already done.

The third wing of the building extends from Congress Avenue to the East and West wards of the hospital, and here are housed the activities more closely associated with the hospital than the School of Medicine. Dr. Clyde L. Deming, well known in the field of genito-urinary surgery is located here. The department of Orthopedics is also on the ground floor. There is also a brace-maker's shop where all the braces required by the hospital and the dispensary are made. On the second floor are located the offices of the staff in Surgery and in Obstetrics and Gynecology. There are adequate private offices and reception rooms to insure prompt service for the clientele of the hospital. A suite of rooms is devoted to prenatal service. This phase of the work is growing and clinics are in constant operation in the hospital and also in other parts of the city. A dormitory suite adjoins the clinic where the personnel engaged in the work may be located in order to be able to work more effectively. A large suite for emergency and accident service is also provided. An enlargement was found to be necessary in order to take care of the automobile casualties. There is elevator service connecting directly with the new operating suite. Here there are sufficient facilities so that eight major operative procedures can be carried on simultaneously. The accessories such as recovery rooms, anesthesia rooms, preparation rooms and supply rooms are provided for each operating room.


(Alumni Weekly)
The New Anthony N. Brady Memorial Laboratory of the Yale School of Medicine. The Hegeman-Harris Company, Inc., Builders. Henry C. Pelton, Architect.

The third and fourth floors have been fitted up as laboratories for the Departments of Surgery, Obstetrics, and Gynecology. Here tests and research may be carried out. The fourth floor of the Cedar Street wing is equipped with dormitory suites for the use of the staff of Pathology and Bacteriology. This allows these men to carry on time-consuming investigations as well as to be available for emergency service such as their departments are frequently called upon to render.

The new building offers greatly increased facilities and space, and is but a step in the expansion which the Medical School has undergone in the past decade and which is expected will be carried on with equal energy in the future.

On Training the Industrial Executive

The Course of Industrial Engineering in the Sheffield Scientific School—Its Similarity to and Difference from Other Engineering Courses

By Prof. Hudson B. Hastings

THE qualifications for an executive in a modern industrial enterprise are far more exacting than they were a generation ago. This country has passed through the stage when the rapid growth of markets and development of rich natural resources can be counted upon to create and sustain a sellers' market. An era of keen competition has set in, under which few companies can survive unless they are under the direction of executives who possess unusual qualifications.

The rapid advance in the technology of many industries during the past twenty-five years has made it particularly desirable to have executives at each level who are able to discuss intelligently with the production and engineering staffs the new processes and machines which are evolved, and their comparative merits with those now in use. If such problems are beyond an executive's grasp he is not unlikely to invest unwisely in new equipment, or to hold to old processes and equipment so long that both the owners of the business and the employees suffer large losses.

The organization of industrial enterprises has become so complex, and the technique of industrial operation so intricate, that technical training in these fields is becoming as essential as in the established branches of engineering.

On both of these accounts, we find that many of our larger industrial enterprises have been compelled to select their operating executives and at least some of their chief executives from among those who have had a thorough technical training and experience.

It is possible for a young man to secure adequate training for executive responsibility solely through practical experience, but this is a long and tedious process. Under the pressure of carrying on the daily routine, his supervisors have little time to assist him in getting a grasp of the principles involved even if they happen to have the ability and inclination to enter into instructive discussions of this nature. It is particularly difficult to acquire a mastery of the technical phases of an industry in this way.

There is also the important consideration that it is almost impossible for the young man without professional training to get a grasp of the operations of any department of the business until he has worked in that particular field for some time, a process that is almost prohibitively time-consuming in the complexity of modern industrial enterprises. If, however, before entering upon his industrial career he has become acquainted with the language and literature of the various phases of industrial enterprise, and has an understanding of the fundamental principles involved, he will be able materially to shorten his successive periods of practical training in the different departments and to secure a much better training, because of his ability to see where the work which he is immediately engaged upon, fits into the conduct of the business as a whole.

Such were the important considerations which led to the conclusion that a special course of study should be worked out to fit the educational requirements of those who were preparing for a career in industry with the expectation of eventually qualifying for positions of general responsibility.

A recent survey of the occupations of the graduates of Yale University shows that approximately one out of every four holds a position of a business or managerial nature in some industrial enterprise. We are therefore studying the educational needs of a relatively large proportion of college men, a group whose size is primarily determined by the relative demands of society for the products of industry as compared with the fruits of other forms of human effort.

The course in Industrial Engineering at Yale has been formulated on the basis of the composite judgment of the faculty and a large number of alumni and others who have attained positions of major responsibility in industry and who have given careful thought to our educational problem.

Nature of the Course.

Approximately one half of the course is devoted to engineering subjects and the necessary preparation for this work in mathematics, physics, and chemistry. In the first place, engineering theory and design has long been recognized as a science and it has been possible, therefore, to work out tested courses of study in this field. Engineering subjects are thus particularly adaptable to classroom and laboratory instruction whereas most of the other types of industrial problems, because they are not yet amenable to the same degree of exact analysis and solution, must be learned more largely through experience. Secondly, it is the most difficult field in which to pursue independent study without guidance in mastering the underlying principles, and finally, the rigorous mental training which it involves helps to establish careful, reasoned methods of analysis and cannot fail to impress upon the student the value of utilizing the scientific method of approach.

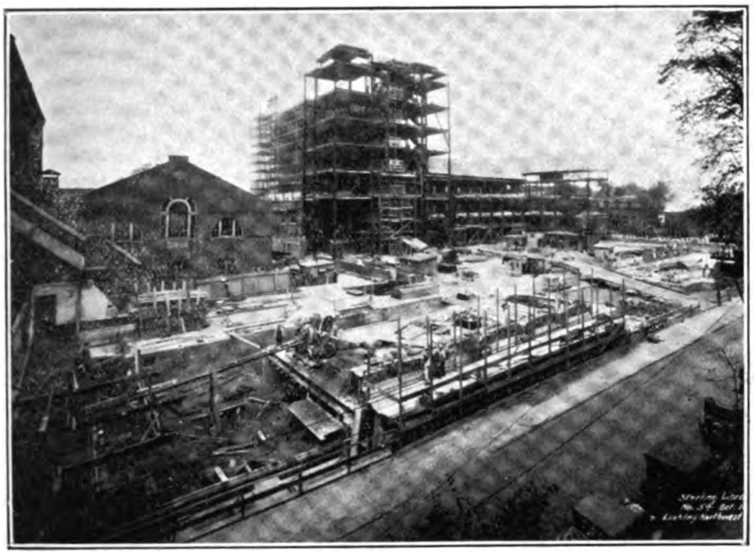
The engineering departments have developed special courses of study for the students of this department in which the mastery of fundamental principles is as important as in the strictly technical courses, but in place of problems exclusively involving the intricate technique of design they have substituted problems which also bring out the economic and personnel aspects of engineering.

On the business side of Industrial Engineering the courses include: Elementary Economics, Accounting, Marketing, Corporation Finance, Plant Organization and Control, Business Law, and Statistics.

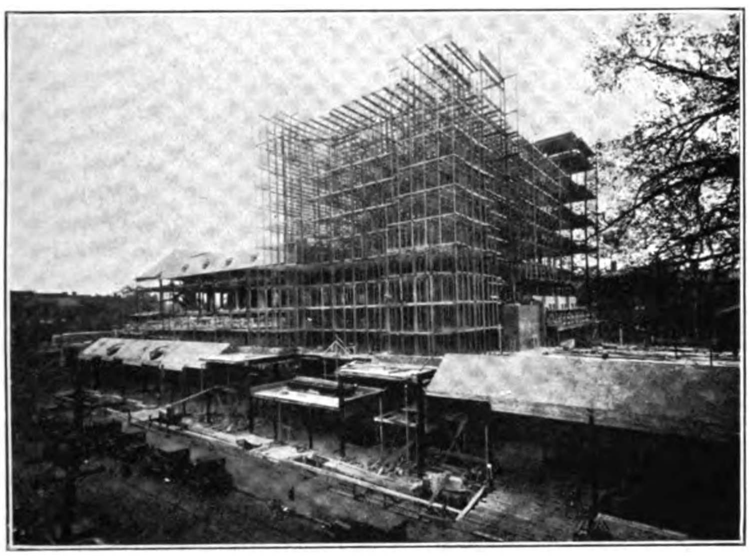
Personnel problems constitute the third group of industrial problems. In both their physiological and their psychological aspects, pioneer work is being done at Yale. After careful study a course has been evolved which sets forth the physiological principles underlying the normal and abnormal operation of the human body, particularly in the environment of industry.

Similarly, the psychological principles underlying the problems of management and human relations have been carefully worked out. These principles have been correlated with the practical problems of the management of personnel, including not only such staff problems as selection and training, but especially the problems rising out of the dealing of an executive with employees and other executives. From this material a discussion course has been developed which aims less to give information

(Continued on page 34)



Views showing the progress of construction on the Sterling Memorial Library. The view above is looking northwest, and the one below is looking northeast.



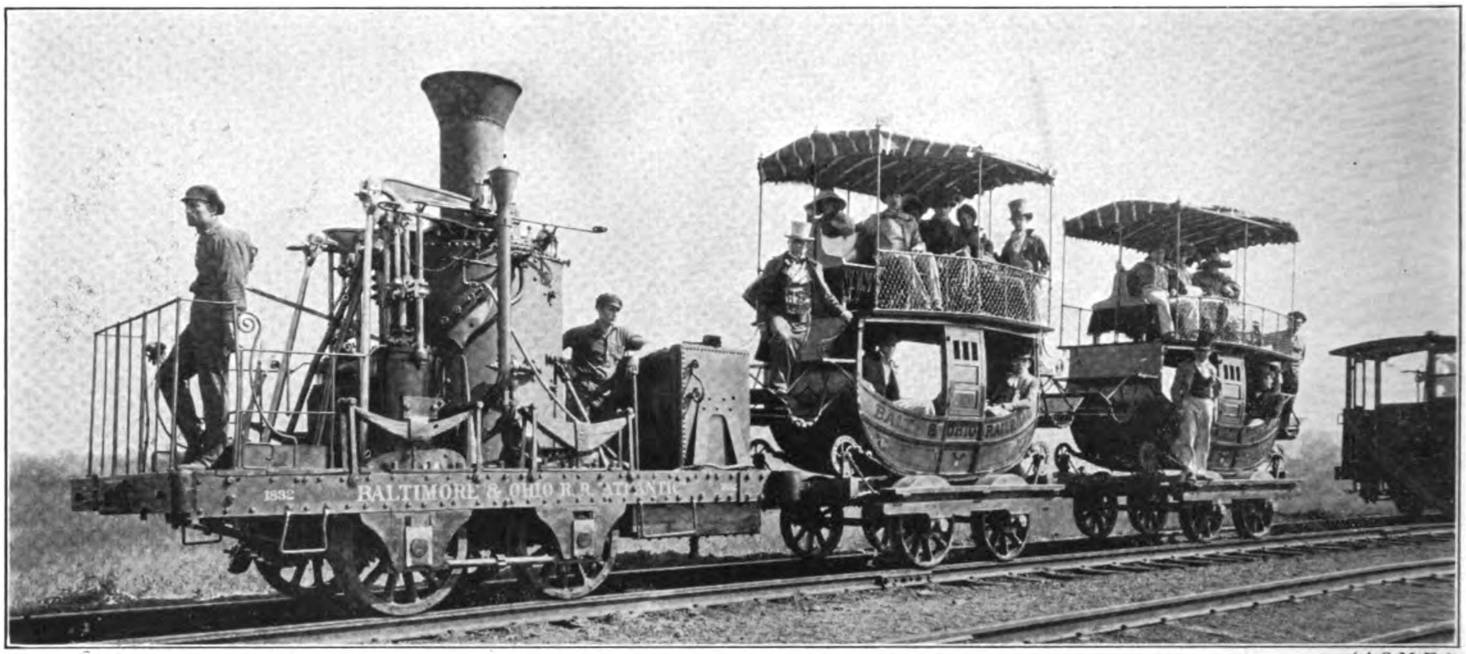
(Underwood)

ABOVE.—*A drill made of Carboloy boring a hole in concrete. This is a new alloy containing tungsten carbide and cobalt which cuts glass and natural sapphire.*

ABOVE.—*Professor Herbert S. Harned (B.A., B.S., Ph.D.—University of Pennsylvania) who has come to Yale from the University of Pennsylvania and has been appointed Professor of Physical Chemistry.*

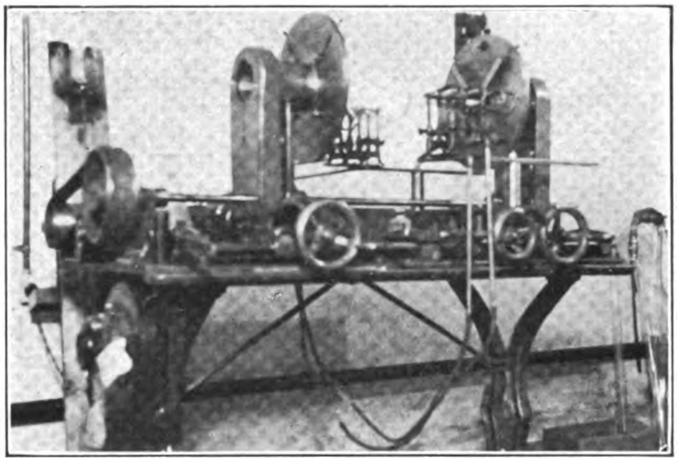
BELOW.—*The Fathometer—a new instrument installed upon the bridge of the "Leviathan" to record the depth of the water under the ship. It takes 23 soundings per minute, measuring depths from 2 to 130 fathoms with an accuracy of a few inches.*

(Underwood)

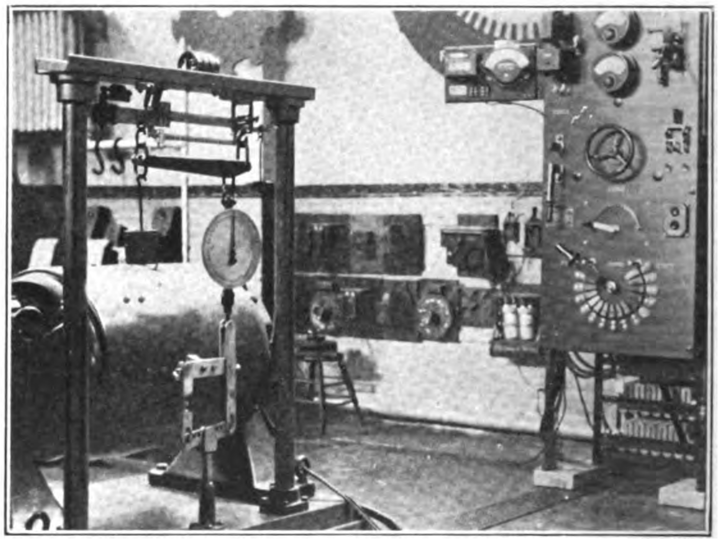


(A.S.M.E.)

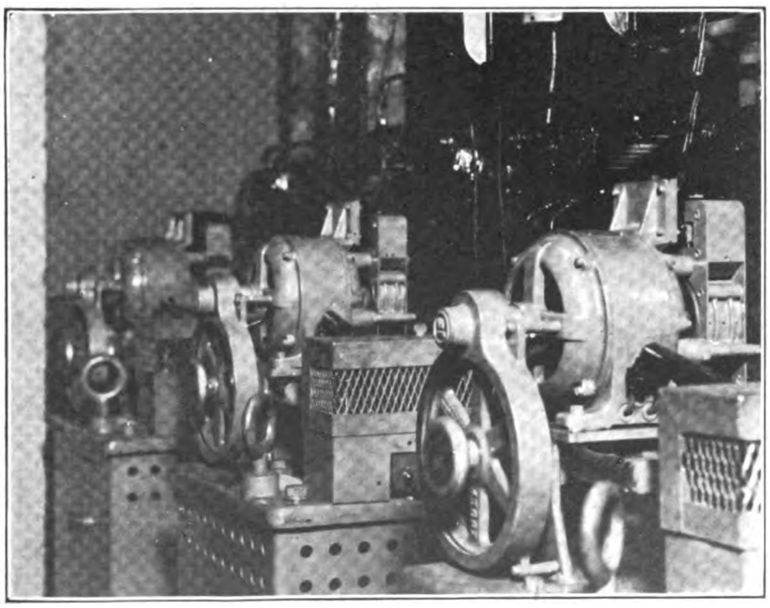
ABOVE.—*The original "Atlantic" of 1812, third locomotive of the Baltimore and Ohio Railroad, with its train of "Imlay" coaches. Contrast this with the locomotive illustrated in article, "The Trend Toward High Steam Pressures," and with the locomotive on the opposite page.*



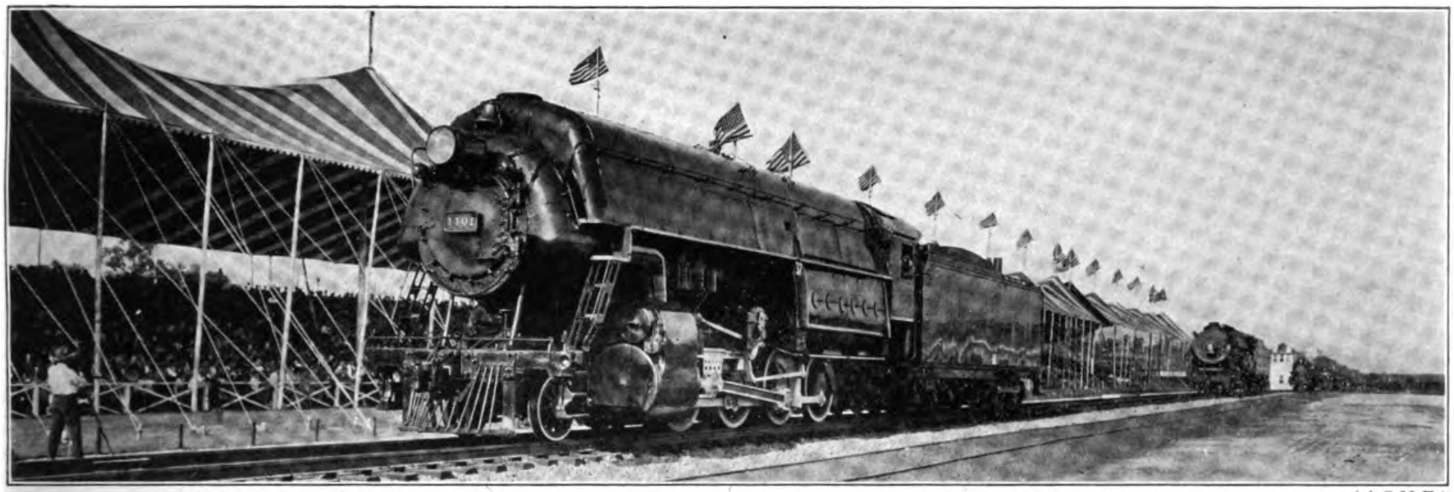
ABOVE.—*The glass-blowing lathe of the Sloane Physics Laboratory, which is being put into condition for blowing bulbs.*



ABOVE.—*This dynamometer set furnishes the most accurate method available for testing motors and generators. The control equipment, shown at the right of picture, as well as the machine is modern in every respect and fills a real need in Dunham Laboratory of Electrical Engineering.*



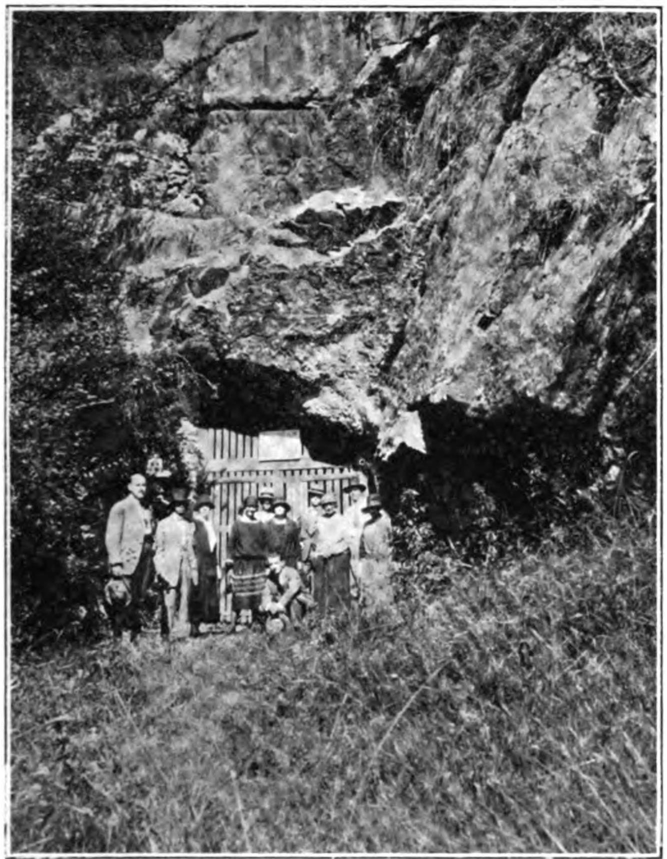
LEFT.—*Induction regulators are frequently placed in obscure places, but they keep vigil to maintain constant voltage on connected circuits. The installation shown is placed at the rear of the switchboard in Dunham Laboratory. It is used to give an improved power supply for laboratory tests.*



(A.S.M.E.)

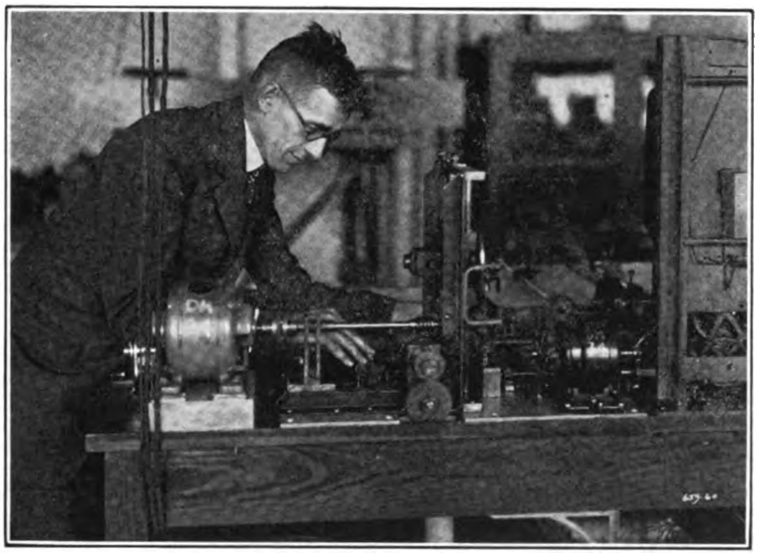
ABOVE.—*The "John B. Jervis" of the Delaware and Hudson Railroad. It is a 2-8-0 Cross-Compound Consolidation type freight locomotive, built in 1927 by the American Locomotive Co. It has a water-tube firebox boiler carrying 400 lbs. pressure.*

ABOVE.—*The dolmen of Mane Bras near Carnac in Brittany, used as a place of burial some four thousand years ago.*

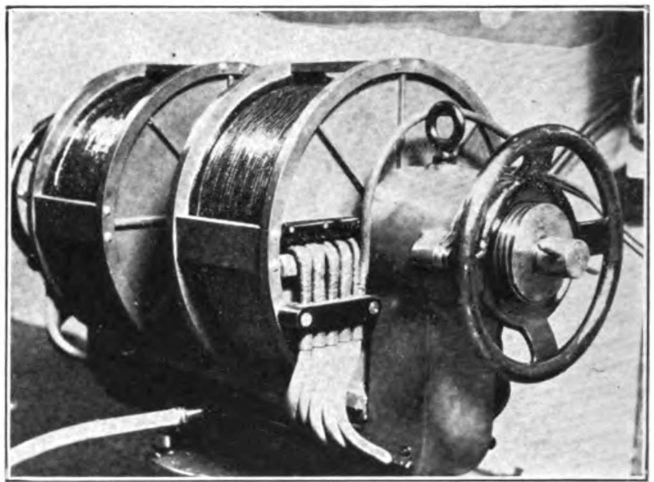


ABOVE.—*Entrance to the cavern of Istruritz in Basses-Pyrénées, France, where prehistoric man left traces of his presence at thirteen successive levels covering a period of at least fifty thousand years.*

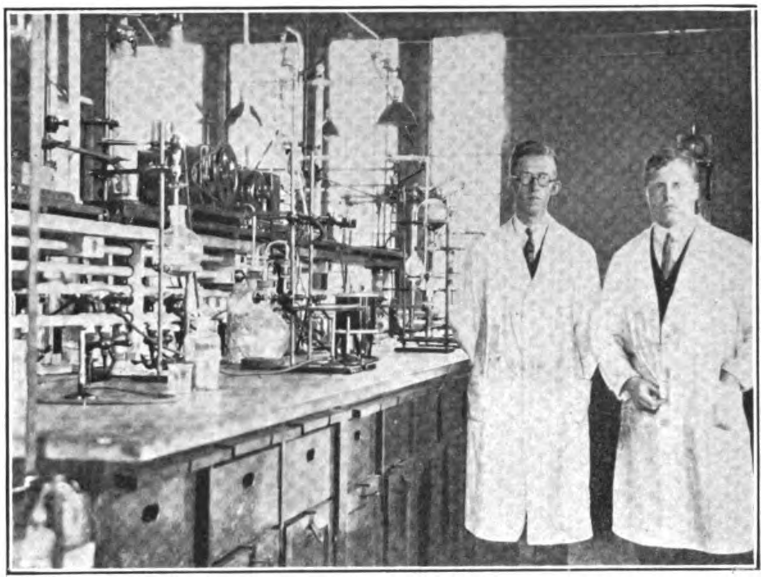
RIGHT.—*The "Abri des Merveilles" at Castel-Merle near Sergeac (Dordogne), France, where students of the American School of Prehistoric Research have dug under the direction of Dr. George Grant MacCurdy since 1924. The man reclining is pointing to the lower of two hearth levels left by Neanderthal man. At this level the four remarkable tools of rock crystal now in possession of the School were found.*



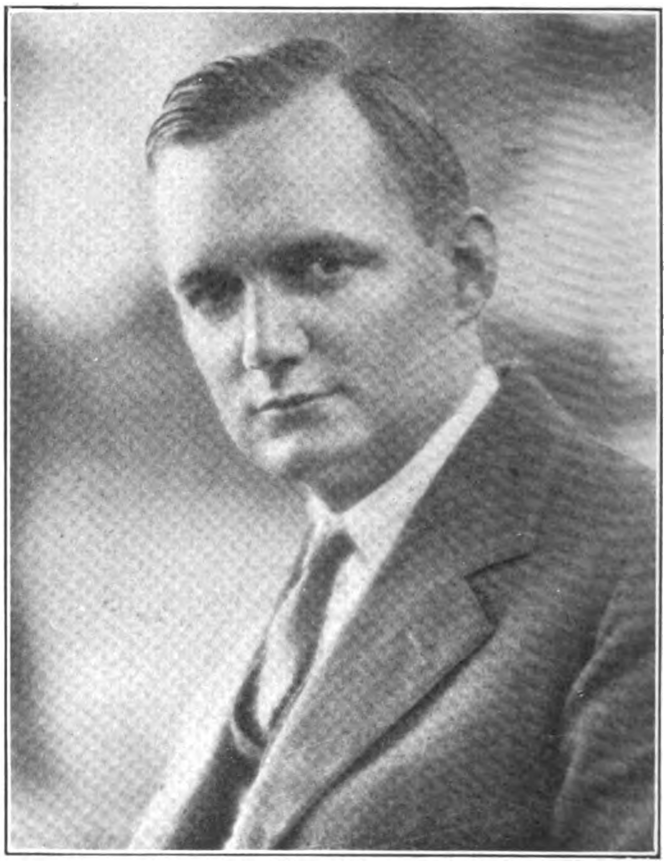
ABOVE.—*The Product Integraph which will write the answer to Mathematical problems too complex for human solution. Dr. Vannevar Bush who developed the machine with F. G. Kear, H. L. Hazen, H. R. Stewart and F. D. Gage is seen adjusting the machine.*



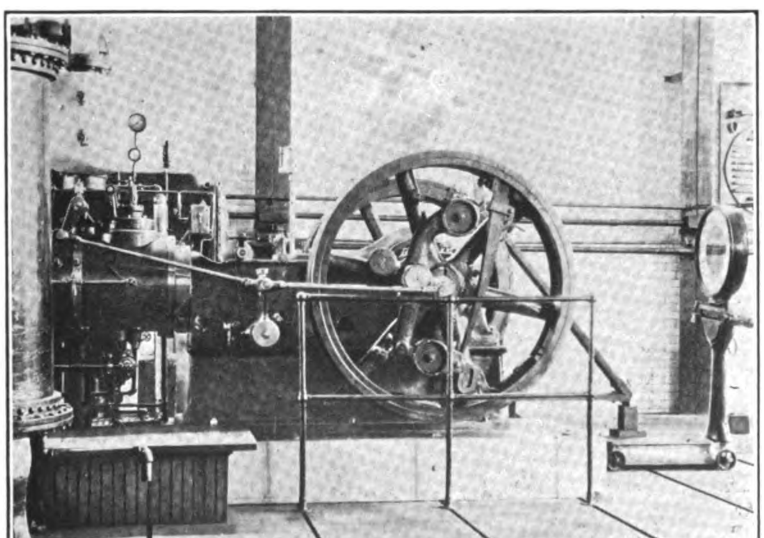
ABOVE.—*Large electro-magnet at Sloane Physics Laboratory which is used in studying the magnetic properties of crystals and magneto-optic effects. Copper tubing is used for conductors, through which water is circulated for sufficient cooling so that a large amount of energy may be dissipated.*



LEFT.—*Dr. Akerlof (right) and Mr. Murphy with the apparatus with which they are taking accurate measurements of electromotive force using waterfree methyl alcohol solutions of strong electrolytes such as alkali sulphocyanides and hydrosulphocyanic acid.*



ABOVE.—*Professor Elliott D. Smith, recently appointed Professor of Personnel Administration. He is former Employment and Division Manager of the Dennison Manufacturing Co.*

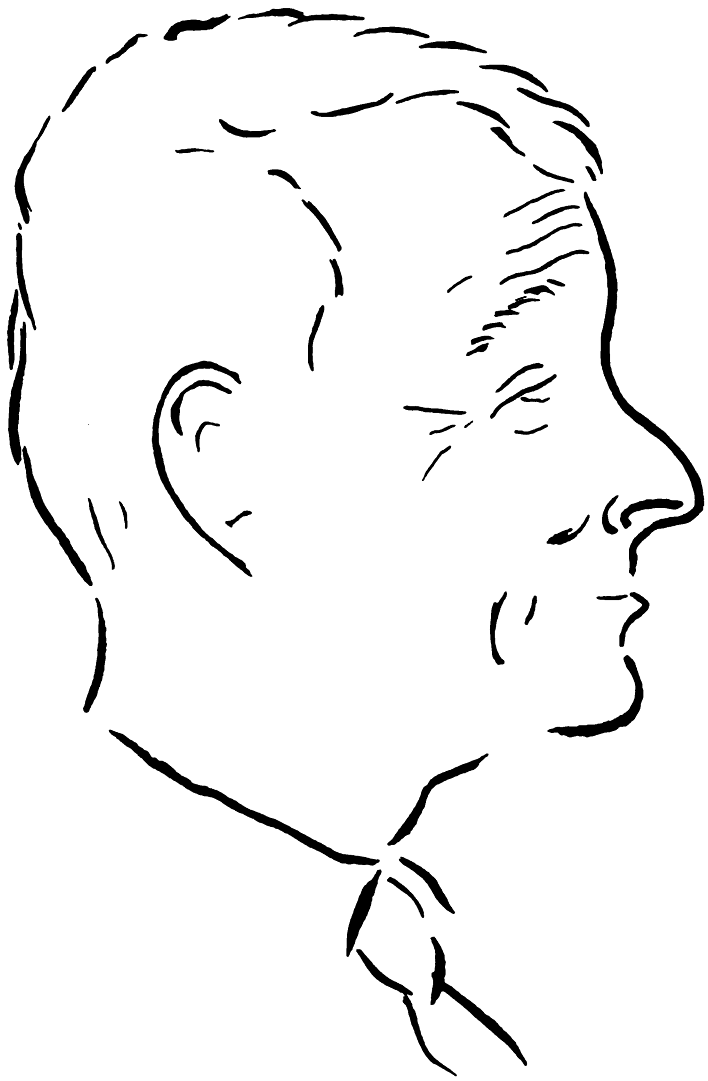


LEFT.—*Large Uniflow Engine in the Mason Laboratory set up with a Prony Brake and scales for an efficiency test.*

P·E·R·S·O·N·A·L·I·T·I·E·S

JACK RANDALL CRAWFORD

THE undergraduate who steps for the first time into Jack Crawford's office in Leet Oliver probably feels that he has finally found the habitat of one who lives up to the popular conception of the professor: a man buried in books to the exclusion of all else in life. For books, papers, pamphlets, catalogues,—printed matter of every kind and description—generously sprinkled with dust and ashes, cover desk, chairs, huge filing cases, and book shelves, overflowing on the floor in a veritable inundation, leaving a narrow channel through which the visitor may gingerly pick his way. Near the window, behind a haze of pipe smoke, sits, however, not the bespectacled, bewhiskered, and wholly impractical dodo who would seem to fit into this picture, but a cheerful individual whose iron-grey hair, ruddy coloring, keen blue eyes, and tweeds make him resemble far more the English country gentleman than the proverbially pallid and round-shouldered scholar.



Should the said undergraduate, judging by the apparently inextricable confusion which reigns in the office, receive the impression that he must be about to deal with a man whose knowledge of books is equaled only by his ignorance of life, a brief conversation will suffice to undeceive him. For the remarkable thing about Jack Crawford, after all, is the variety and scope of his knowledge and interests. Family connections in England and frequent travel have made him thoroughly at home in the British Isles and on the Continent, and have given him a cosmopolitan point of view. Actual experience in business and mining, with a scientific training, have acquainted him intimately with a side of life of which most professors of English are relatively ignorant, and have made him peculiarly fitted to direct the study of English in a Scientific School. A track man at Princeton, a well-known figure on the tennis and squash courts at the Lawn Club as well as on the beach at Madison both in and out of season, and an enthusiastic follower of football,—it was only natural for him to be selected as a member of the Board of Control of the University Athletic Association. Playwright and student of the drama, he has combined theory with practice, and is a director of the Playcraftsmen and of the University Dramatic Association as well as founder and leading spirit of the Little Theatre Guild of New Haven. Though the drama is his special field in letters, he is, so far as is known, the only member of the English Department to have written, published, and sold a novel. Meanwhile, his latest production, *What to Read in English Literature*, is a guide, written for the layman, to the entire subject.

From what has just been said, it should not be inferred that any of these multifarious activities would be divulged to the casual visitor. Jack Crawford is nothing if not secretive about his own accomplishments: that is one reason why this article is being written. But even a short time in his office will leave our undergraduate with an impression of the man wholly different from his view of the room; an impression of a keen and orderly mind, of a sympathetic personality, and of an extraordinarily wide range of information. What will surprise him as much as anything else will be the prestidigitation with which Mr. Crawford can retrieve from the surrounding chaos any given paper he happens to want.

Professor Crawford's "vital statistics" are not particularly illuminating to one who does not know him; they can be found in *Who's Who.* Born in Washington, D. C., in 1878, he took his B.A. at Princeton in 1901 and his M.A. at the same university two years later. Since 1909 he has been at Yale as instructor, assistant professor, and associate professor of English. He is married and has three daughters. His home on Lincoln Street, as many undergraduates know, is conveniently near the university. It has even more books than his office, but some power keeps them in order. His summer home is at Madison. He is a member of numerous clubs, including, in the university, Vernon Hall, the Aurelian Society, and the Elizabethan Club, but he is a clubable man rather than a clubman, which is an important distinction.

One of his activities which is of vast importance to Yale and to education in general, but of which little is known here either by his students or his colleagues is his connection with the College Entrance Examination Board. For years he has been Examiner and Chief Reader for the Comprehensive English Examination, in which double capacity he has, more than any other single person, been responsible for the form which that paper has assumed and for the standards by which it is marked. As Chief Reader he is in charge, each June, of the scores of English teachers from schools and colleges all over the country who grade the Comprehensive English Examination. These readers have, naturally enough, widely varying opinions and background, and it requires sound judgment and diplomacy of no mean order to achieve harmony and maintain

(Continued on page 40)

Physics

Prof. A. T. Waterman and Prof. R. S. Bartlett are back at Yale after spending a year's leave of absence in London.

The Department of Physics has recently purchased a powerful electro magnet with part of the Sloane funds. The magnet is water cooled to prevent overheating by the high value of current passed through it. It is to be used in studying the magnetic properties of crystals and the magneto-optic effects.

More of the Sloane funds have been used in purchasing a number of very fine Lummer-gehrcke plates for the analysis of the fine structure of spectral lines.

Prof. D. A. Kreider has been granted a second year's leave of absence and will not return to Yale until next fall.

Mining and Metallurgy

The annual mine inspection and surveying trip for the Senior class in Mining began on Labor Day at Sudbury, Ontario, Canada. The party of five, in charge of Professors Warner and Behre, travelled by automobile, and a distance of about 2500 miles was covered. During the course of the trip opportunity was given to study copper-nickel mining, milling, and smelting at the International Nickel Company and the Mond Nickel Company in the Sudbury District; native silver mining and milling at the mines of the Mining Corporation of Canada and the Nipissing Mining Company at Cobalt, Ontario; gold mining and milling in three important mines in the Kirkland Lake District of Ontario and at the Hollinger Consolidated and the McIntyre Mines in the Porcupine District. After looking over these Ontario mines the party spent three days in the new copper district at Noranda, Quebec, and then turned to the United States where the iron mine and smelter of the Chateaugay Ore and Iron Company at Lyon Mountain, New York, and that of Witherbee-Sherman and Company, at Mineville, New York, were studied. At the last named property the usual course in mine surveying was given.

Professor R. K. Warner spent the greater part of July and August studying mining methods at the large copper mines in Arizona. In all, a total of nine mines were visited.

At the first meeting of the Mining and Metallurgical Society plans for the coming year were discussed, and officers elected as follows: C. P. Knaebel, President, and L. W. Adams, Secretary. This Society is the oldest affiliated student society of the American Institute of Mining and Metallurgical Engineers.

A 35 KVA Ajax Northrup high frequency melting furnace has been installed in the Hammond Metallurgical Laboratory. With this furnace it will be possible to melt alloys which could not formerly be prepared with the low temperature melting equipment available in this Department.

In October Professor Mathewson presented a paper on Neumann Bands in Ferrite before the joint meeting of the American Society for Steel Treating and the American Institute of Mining and Metallurgical Engineers, in Philadelphia.

Professor Phillips has revised the Copper-Zinc Constitutional Diagram. This work has been published in the 1929 Handbook of the American Society for Steel Treating.

Doctor W. H. Hadfield, Director of Research of the Brown-Firth Laboratories, Sheffield, England, gave two lectures at the Hammond Metallurgical Laboratory during October. The subjects of his lectures were (1) Rust and Acid Resisting Steels, and (2) Tool Steels—Both Carbon and High Speed.

Civil Engineering

This year the Senior Class in Building Construction had a particularly interesting inspection trip in New York City. The two weeks following Labor Day were spent in visiting building operations and manufacturing plants producing building materials. We were extremely fortunate in having a personally conducted tour through the 58th Street subway and an excellent description of the work on the towers and anchorage of the new Hudson River Bridge, given by the Resident Engineer representing the Port Authority.

The remainder of the time was devoted to the field of building construction. Visits were made to representative buildings of all types including the new Grand Central Building, a modern apartment house, the Cathedral of St. John the Divine, a factory and a furniture warehouse. The jobs were chosen to illustrate the various types of construction and, fortunately, were in very interesting stages.

As in previous years the success of the trip, the object of which is to give the men a bird's-eye-view of the industry, was due to the splendid co-operation of the building profession.

Biology

The laboratory opens this term filled to its capacity with graduate students and visiting scientists, including Dr. Brien of Belgium; Professor Filipjev of Russia, who is a Nematologist; Dr. Petar Martinovitch of Serbia, who is studying Tissue Culture; and Dr. Wang of China, whose study is Protozoology.

Professor Harrison, who has spent the past year and a half abroad, has returned to the directorship of the laboratory. Reports of investigations observed and meetings attended by him have formed the basis for two informal lectures before the laboratory staff.

The resources of the laboratory are being used to capacity. An extensive program of work in experimental morphology, physiology, genetics, protozoology, and systematic zoology is scheduled for this year.

Mechanical Engineering

At the annual meeting of the American Society of Mechanical Engineers Professor W. J. Wohlenberg and Mr. R. L. Anthony will present a paper on "The Influence of Coal Types on Radiation in Boiler Furnaces," and Professor E. O. Waters a paper on "A Graphical Method for Least Squares Problems."

Professor Waters' paper is an outgrowth of his work last summer for the Keystone Aircraft Corporation of Bristol, Pa., involving the analysis of stresses in an airplane structure. Professor Waters was present on November 5 at the trial flight of the Keystone Corporation's "Patrician," a twenty-passenger transport plane.

Professor H. L. Seward has been appointed as the University's representative at the inauguration of Dr. Harvey N. Davis as President of the Stevens Institute of Technology. He will also participate in a series of tests at the Philadelphia Navy Yard by the Fuel Conservation Committee of the U. S. Shipping Board and as an observer on the trial trip of the S. S. "Virginia," a new electric drive vessel of the Panama Pacific Line.

Professor L. C. Lichty will present a paper at the coming annual meeting of the Society of Automotive Engineers on "High Compression and Anti-Knock Fuels" and a paper on "The High Pressure Combustion of Hydrogen" for the Transactions of the American Society of Mechanical Engineers.

Professor S. W. Dudley is Chairman of a special committee of the American Society of Mechanical Engineers, which is planning the celebration of the 50th Anniversary of the Society to be held in Washington, D. C., in April, 1930. He will preside at a conference of committees of The American Railway Engineering Association, the Society for the Promotion of Engineering Education, and the Railroad Division of the American Society of Mechanical Engineers, and representatives of the railroads on the Relations of the Colleges and the Railroads, to be held during the Annual Meeting of the A.S.M.E. at New York during the first week of December.

Mathematics

Professor E. W. Brown has resumed his work after taking a half-year leave of absence.

Professor O. Ore and Dr. T. H. Rawles attended the meeting of the International Congress of Mathematics held at Bologna, Italy, in early September.

The summer meeting of the American Mathematical Society, held at Amherst College, was attended by the following members of the department: Gehman, Pierpont, Tracey, and Wilson. A paper was read by Professor Wilson.

Mr. H. L. Dorwart, instructor in Mathematics for the last three years, has accepted a position at Williams College.

Mr. C. Naylor, Ph.B. 1926, has been appointed an instructor in Mathematics.

P. R. Rider, Sterling Research Fellow in Mathematics for the year 1928-29, is now in residence. Mr. Rider is on leave of absence from Washington University of St. Louis where he is an Associate Professor of Mathematics.

Medicine

Dr. F. d'Herelle, eminent bacteriologist, has recently been appointed Professor of Bacteriology at the Yale University School of Medicine. His varied career has included work with the Pasteur Institute, service for the governments of Guatemala and Mexico, and research work in Argentina, Asia Minor, Tunis, and India.

Dr. J. R. Paul, who has been doing graduate work at the University of Pennsylvania, has been appointed Assistant Professor of Medicine.

Dr. D. C. Darrow has been appointed Assistant Professor of Pediatrics. He was previously Instructor in Pediatrics at the Washington University School of Medicine.

Electrical Engineering

Mr. A. G. Conrad comes to the department as an instructor. He is a graduate of Ohio State University who continued there as a graduate assistant and received a Master's degree. He has taken the test course at the General Electric Works in Schenectady.

Professor W. B. Hall spent the summer in New Haven working on condenser problems for the Acme Wire Company and developing an electric furnace for the Bellis Heat Treating Company. A description of this furnace appears on another page of this issue. The graduate students in his course "Industrial Applications of Electricity" have had a hand in this development and are in touch with it in its present stage.

An electric clock has been presented to the Engineering Reading Room in Dunham Laboratory by R. C. Lanphier, 1896 S., President of the Sangamo Electric Company, Springfield, Ill. The Sangamo Company is engaged principally in the manufacture of high grade meters and has recently developed an electrically wound clock. This will be a very useful addition to the Reading Room.

Promotions in the department are indicated by the new titles of Associate Professor A. E. Knowlton and Assistant Professor F. T. McNamara.

Mr. S. K. Wolf, who has been with the department as an instructor for a number of years, has resigned and is now with the Electrical Products Corporation, Inc., and is engaged in the development of the vitaphone.

Mr. R. B. Dodds, Jr., who was last year an instructor in the department is now engaged with the Electromatic Signal Corporation of New Haven which is introducing the automatic signal system invented by H. A. Haugh, Jr., recently an instructor in this department.

A course in Illuminating Engineering has been instituted this year in the graduate group of courses, one of the class members specializing on stage lighting and another on airport and airway lighting. These courses are under the direction of Professor Knowlton.

Professor C. F. Scott was Chairman of the Connecticut Hoover Engineers Committee and among those on the State Committee during the campaign was Professor Knowlton. Professor Warner was a member on the Local Committee for New Haven.

The annual Convention of the Society for the Promotion of Engineering Education was held at the University of North Carolina, Chapel Hill, in June. It was attended by Dean Warren, Professor Dudley and Professor Scott.

The convention brings together a group of several hundred engineering teachers and some representatives of education in industry for the presentation of papers and the discussion of educational problems. The first award of the Lamme Medal for "Accomplishment in Technical Teaching or actual Advancement in the Art of Technical Training" was made to Professor George F. Swain, Professor of Civil Engineering at Harvard. Mr. B. G. Lamme, late Chief Engineer of the Westinghouse Electric and Manufacturing Company, provided in his will for three medals, one to be awarded by the educational society, one by the Ohio State University and one by the American Institute of Electrical Engineering. Professor Scott is Chairman of the A.I.E.E. committee on the award of the medal.

Forestry

A new laboratory for instruction and research in Forest Soils has been established in the large tower room in Sheffield Hall. The work is carried on under the direction of Mr. M. F. Morgan of the Agricultural Experiment Station, who this year has received an appointment as Research Associate in Forest Soils in the School of Forestry. This is an important new departure in the Forest School. The courses offered and research facilities are of importance both to the School of Forestry and to other departments in the University.

The summer session of the School of Forestry was conducted, as during the previous year, at the Yale Engineering Camp at East Lyme. The term covers a period of nine weeks which is dovetailed between the June and September sessions of the engineering classes of the Scientific School.

The tract of nearly 2,000 acres, owned by the Scientific School, serves admirably for the field work of the Forestry classes. Mr. G. F. Rupp was in charge of the Forestry group. Mr. R. B. Allen, assisted by Mr. L. E. Wooten, handled the Surveying features of instruction. There were fourteen students in the class.

Dean Graves recently addressed the Philo-technical Society at Berlin, New Hampshire. The great paper and pulp manufacturing plant of the Brown Company is located at Berlin. This is one of the largest concerns of its kind. The Company maintains a large laboratory of research. Nearly a hundred persons are connected with the research organization. The Company is interested in Forestry and has set aside ten thousand acres as an experimental forest near Berlin.

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

PLANS for the new building to replace South Sheff., an improvement for Sheff., that this Association has long advocated and labored to bring about, are still in the formative stage but it is likely that some definite announcements can be made within a few months. Mr. C. C. Zantzinger has been engaged to prepare the plans and at the present time is working with the University authorities to solve the architectural problems. The building will occupy a commanding vista at the end of College Street and the problem is for that reason a difficult one. It must be made to harmonize with the surrounding structures, Woolsey Hall and Byers Hall, and its position demands that it contain an impressive tower. In addition, the lot it will occupy is an irregular one and Mr. Zantzinger is having difficulty in meeting the many exterior requirements of the building and yet fit the interior to the needs of the School. Several weeks ago he appeared before the Architectural Plan Committee of the University with preliminary sketches. At the present time they are being worked over by Dean Warren with the various groups interested in its interior.

We shall probably be able to present some definite idea as to the exterior of the structure in our January issue.

* * *

WE hear much these days about the so-called trend away from an engineering education and there are many calamity criers who have predicted that as a result Sheff. would find herself studentless. An informal communication we received some time ago from Dean Warren relative to the Class of 1931 which entered Sheff. this fall is sufficient to dispel any belief in such rumors as succeeded in surviving the very searching analysis of the Sheff. population problem made last year by Mr. Crawford's Bureau of Personnel Study. Dean Warren tells us that the new class is as fine as we ever had and that its numbers, 245, constitute a slight increase over the Class of 1930, in spite of the fact that the Freshman Class last year had a pretty high mortality rate.

Dean Warren further observes:

"In the entering Freshman Class the indications are that there is a still larger group of boys who are heading this way and, as we know, their preliminary choices are a pretty accurate indication of their final choice of course.

"Regarding changes in staff I should like to call your attention to the fact that two important promotions have been made, Mr. Seward and Mr. Wohlenberg to be full professors of Mechanical Engineering. Mr. Wohlenberg's special field of work relates to power engineering. He is internationally recognized as one of the leading authorities in this field. Professor Seward has developed most successfully work here relating to questions of plant lay-out and management, or perhaps I should better say, the principles which any young man going into industrial work should be familiar with as a basis for getting along successfully when he enters upon actual practice. Mr. Seward has also made a specialty and is widely known for his work in marine engineering. They are both very strong men and we are fortunate indeed to be able to enroll them as permanent members of our staff.

"Mr. Elliott D. Smith has been appointed Professor of Industrial Management and will devote himself particularly to problems of personnel management. He will give instruction in this subject formerly given by Professor Hastings and will, in addition, carry on investigations in this field in which he is widely and favorably known. Mr. Smith is a graduate of Harvard University and of the Harvard Law School and has for some years been connected with the Dennison Manufacturing Company, having entire charge of all matters relating to personnel work. In connection with this work he has given much attention to matters of industrial psychology and is regarded as an authority in this field also. For the past two years he has lectured at the Harvard Graduate School of Business Administration and has also given courses for industrial executives. He is easily one the outstanding men in this line, both from the point of view of practical experience and of research and study. We are most fortunate in securing him."

Regarding the housing problem, Dean Warren says:

"As you doubtless are aware, the most urgent need of this School in my mind is an adequate and suitable dormitory quadrangle and campus. We have made a good beginning in this direction in the present Vanderbilt-Sheffield dormitories and we hope we shall see them completed in the near future. When this is realized, we shall have one of the finest quadrangles in the university or anywhere else, and we shall then be in a position to offer not only suitable living quarters for our students but all those associations and influences which center about a college campus and which in reality form so intimate and valuable a part of a young man's education and experience. This need of a campus and dormitories is to my mind at the moment the outstanding need of the School."

The dormitory problem was also singled out by President Angell at the opening of the present college year as the most pressing need of the University. The Association has been working indirectly for some time for the completion of the Sheff. quadrangle. There is no doubt but that the lack of proper housing facilities for the non-fraternity upper classmen in Sheff. has kept many would-be engineers away from Sheff. and even Yale.

However there is one phase of the Sheff. housing problem which should be studied carefully before it is tackled. President Angell has remarked that the present system of allowing Sheff. Juniors and Seniors to live in fraternity houses was only a temporary solution of a pressing lack of space. Yet it is safe to say that the house system does give Sheff. a number of social nucleii which the College lacks and it is around these centers that most of the extra-curriculum life of Sheff. centers. Many consider the Sheff. clubs among Sheff.'s strongest assets and although they are in every mind subsidiary to the best interests of the School, let us be certain of their uselessness before we abandon them.

WHY A BOY SHOULD GO TO THE SHEFFIELD SCIENTIFIC SCHOOL

[NOTE: *The following letter by Oliver S. Lyford, 1890 S., will undoubtedly be of interest to many alumni who are asked this important question. His answers will no doubt suggest other phases of the same question and other answers. The officers of the Yale Engineering Association are anxious to have all such questions and answers and request that they be communicated to the Secretary, Mr. Billings Wilson, 75 West Street, New York City.*]

Bronxville, N. Y.

Mr. Smith F. Ferguson,
President, Yale Engineering Association.
Dear Ferguson,

You and I have discussed with various groups of alumni the advantages to Yale and particularly to the Sheffield Scientific School which would result if certain alumni in different parts of the country were ready to advise with prospective students regarding the courses of study at Yale and other matters concerning which a boy and his advisers need information. Also we have considered the possibility that such alumni might be of assistance to the Board of Admissions by interviewing the candidates of different localities at a distance from New Haven.

These discussions have shown a general willingness to help in the matter, but we are often asked how the alumni are to be put in position to advise wisely and particularly what reasons we shall give for a boy to go to the Sheffield Scientific School rather than to some other university or technical school.

You have asked that I answer some of these questions and I submit the following for your consideration.

In some ways it should be easier for me than for Dean Warren or any of the members of the faculty to discuss the merits of Sheff. and its personnel and facilities. One of our difficulties lies in the natural reserve of any successful engineer or scientist. As a class, we are not good at selling ourselves. A good engineer is so completely absorbed in trying to get at the truth and so conscious of what he does not know, that he hesitates to say how much of a fellow he is. Consider, for instance, Mr. Hoover. The Sheff. faculty is made up of real men and therefore has this characteristic to a somewhat unusual degree.

My position is that of an investigator and critic, having no official connection with the University, but being an engineer and business man associated with other alumni of the Yale Engineering Association in an effort to be of assistance to the University in developing the Scientific School and keeping it at the front in educational lines. I am more closely in touch with the Engineering Division of the School than with the scientists, but as the result of many interviews and discussions, I feel that I am familiar with both.

In the first place, this is an important selective operation, on which the alumni are asked to help. Already the number of boys trying to enter Yale each year is more than twice the number that the University can take. It is not numbers but personal worth that we are after. What is wanted from the alumni is assistance in finding each year the boys best fitted by background, personal and intellectual qualities, and purpose, to utilize the opportunities afforded by the Sheffield Scientific School in preparation for careers in science, engineering and the technical and administrative sides of industry and commerce.

The school has capacity for about 300 students each year which is less than 2 per cent of the total number entering engineering schools. We want this 2 per cent to be the best available.

A large majority of the boys headed for college can undoubtedly do as well in the state universities and smaller institutions as at the great national universities such as Yale. The special opportunities which our university offers should be made available only to those who have the stamina to make the best use of them and those who have promise of careers which will prove the worth of Yale men. Obviously, this problem in selection is a difficult one and its solution is a matter of continual improvement in our methods and the proper enlightenment of our alumni. It affords an opportunity for fine service and I am sure qualified graduates will find it very interesting.

Going now to certain specific questions, the following answers are offered:

We are asked whether this effort is proposed because Sheff. is not getting the right kind of boys now. Mr. Crawford, head of the Department of Personnel Study, has made careful studies which show that of the boys now in Yale, a much larger proportion are good intellectual material than in your time and mine. The methods of testing now used by the Board of Admissions, together with the larger number from which to select, are mainly responsible for this. That there is a larger proportion of boys with high character, particularly in the Scientific School, is evident in many ways. However, there is reason to believe that, with the assistance of the alumni, these proportions can be materially increased.

We are asked how our equipment compares with that of other colleges. In this connection, our alumni no doubt realize that equipment available for Sheff men includes the great university laboratories of physics (Sloane), chemistry (Sterling), biology and botany (Osborn) and the Peabody Museum, as well as the mechanical (Mason), electrical (Dunham), mining and metallurgical (Hammond) and engineering mechanics laboratories of the Scientific School. There can be no question that these laboratories rank with the best of the country. In addition, there are the facilities for scientific and engineering work in the many industrial establishments of various kinds in the vicinity of New Haven.

Next, are we able to pay adequate salaries and the necessary expenses? The budget hitherto has been handicapped because of insufficient endowment. Now this has been adequately remedied by the recent drive and, as the subscriptions are gradually paid in, the budget will meet all necessities.

We now come to perhaps the most important question: What about the teaching staff of the Sheffield School? Are the men of our faculty in the first rank of educators and do they understand what the young men of the present day will be up against?

In the first place, I would like to refer to the coordinated effort being made by the educators of the country (in the Society for the Promotion of Engineering Education) to determine upon the best curricula and the best methods of instruction for boys preparing for technical and administrative careers in industry. In no other branch of education is there any united effort which approximates this and the results already have been far reaching. Our Professor C. F. Scott has been one of the most active leaders in this organization and Dean Warren has been chairman of the Committee on Personnel. Extensive researches have been made into the requirements of the nation and the courses of study and methods of teaching best adapted to these requirements.

Obviously our faculty is fully advised in all these matters. Incidentally I have sat in a number of large gatherings of this Society and can assure you that the members of our faculty are perfectly competent to hold their own with the best.

Regarding the individual members of the faculty, I can illustrate their character and effectiveness best by brief statements

regarding those of whom I know the most. As all professors and instructors have been selected after measurement by the same high standards, it is fair to assume that these men afford a fair indication of the kind of men that form the large majority of the Sheff. educators.

Charles H. Warren—Dean of the Sheffield School and Professor of Geology since 1922. Previously Professor of Geology at Massachusetts Institute of Technology and Chairman of its Committee on Courses of Instruction. Obviously familiar with all the best traditions and educational policies of M. I. T. (For further information see article in YALE SCIENTIFIC MAGAZINE of May, 1928.)

John C. Tracy—Professor of Civil Engineering and head of that department. In addition to eminent work in civil engineering, he has been closely associated with the business men of New Haven as President of Kiwanis and President of the New Haven Chamber of Commerce.

Samuel W. Dudley—Professor of Mechanical Engineering and head of that department. With Westinghouse Air Brake Co. in various capacities, 1905-1921; Assistant Chief Engineer, 1910-1914; Chief Engineer, 1914-1921. Professor at Yale since 1921. Specializes in experimental engineering; eminently practical as well as scientific.

Hudson B. Hastings—Professor of Industrial Engineering and head of that department. Professor of Drawing and Surveying, Reed College, Portland, Oregon, 1911-14; Professor of Applied Economics, Reed College, 1915-20: Chairman Fresh Fish Division of Federal Food Administration for Oregon, 1917-18; Auditor and Adviser, Portland Milk Commission, 1918-19; Research Economist, Frank D. Pollak Foundation for Economic Research, Newton, Mass., 1920-23; Professor at Yale since 1923. Specialist in economics and business practices of industry.

Charles F. Scott—Professor of Electrical Engineering and head of that department. A leader well known in the entire engineering world. Formerly Chief Electrician of the Westinghouse Electric & Manufacturing Co. (For further information, see Article in YALE SCIENTIFIC MAGAZINE of March, 1928.)

Champion H. Mathewson—Professor of Metallurgy and head of the Department of Mining and Metallurgy. Instructor in Metallurgy, Massachusetts Institute of Technology, 1906-7; with Yale since 1907; Professor of Metallurgy since 1919. Specializes in studies on constitution of alloys and recrystallization of metals; consulting expert for United States Steel Co., New Jersey Zinc Co., Scovill Manufacturing Co. and others. Recognized as one of the leading authorities on physical metallurgy.

Herbert L. Seward—Professor of Mechanical Engineering. Planned and put into operation and has since directed, the summer course in Mechanical Technology. Organized and teaches the course in Industrial (Plant) Management. Specializes also in nomography and marine engineering. Expert to the U. S. Shipping Board with reference to fuel conservation. Has made many trial trips studying power plant development of vessels including the *Leviathan*. Has also made extensive studies of factory management in large manufacturing concerns. Carries a heavy load of teaching duties.

Walter J. Wohlenberg—Professor of Mechanical Engineering. Teaches thermodynamic power engineering and power plant problems. Has carried on research work in combustion of fuels at high pressures, also on furnace temperature and radiation. Has served as mechanical engineering expert on a number of large practical power plant problems. Has been president of Sigma Xi, the national honorary engineering fraternity.

I have made these statements very brief. Each individual has done a large amount of creditable work, some of which is touched upon in *Who's Who in Engineering* and *Who's Who in America*, where the records of many of our men may be found.

The above paragraphs show clearly one of the very important features of the educational potentialities of our school, namely, that the teaching is done with a background of personal knowledge of the actual scientific and administrative requirements in life after college. This, in many ways, is the most distinctive difference between education in an arts college and in an engineering or scientific school. In the former, the background of the faculty is essentially that of the arts, history, languages, literature, etc., whereas in the latter the background is essentially that of the activities of an industrial age.

This is no adverse criticism of the classical courses. Such courses in the college are best suited to more than half of the boys who matriculate at Yale, but those who must plunge into the strenuous life of engineering, industry and commerce, after only four years of preparation, will probably be wise in associating themselves with educators who not only know how to teach their subjects but who know from personal experience what the boys will be "up against."

For further information regarding the activities of our faculty in constructive research and creative thinking, the issues of the YALE SCIENTIFIC MAGAZINE should be consulted. The articles are readable and interesting as well as instructive. Does not this in itself show that these men know how to "get their subjects across"?

Coming now to the teaching qualifications of our faculty members, I cannot speak from personal knowledge but I wish you could have sat with me recently in Dean Warren's interesting farm house near Litchfield, and heard him go right through his faculty and list those who are good teachers. Of course the ability to teach is a rare one but I am sure anyone would be impressed with the large number of our men who have this ability.

I hope I have answered these questions in a way that carries conviction. We do not claim unqualified excellence for the Sheffield Scientific School. There is, however, ample evidence that it now ranks with the best and is continually getting better.

Add now the benefits of the traditions, fellowship, cultural influences, university atmosphere and other things which all Yale men value and love, and there is abundant reason for an alumnus to claim that undergraduate life in the Sheffield Scientific School is something to be sought after by those who are fitted to profit most by it.

Yours very sincerely,

O. S. LYFORD.

* * *

HARVARD IS HOST AT JOINT MEETING.

THE Harvard Engineering Society will be the hosts this season for the annual joint meeting of the engineering societies of Harvard, Yale and Princeton. The meeting will be held at the Harvard Club in New York City on January 18 and the program will include a lecture by the internationally famous Dr. Traprock on his "Latest Explorations and Discoveries" illustrated by lantern slides. It will be remembered that last year our Association was host for the evening at an evening devoted to aviation.

* * *

"EVERY MEMBER GET A MEMBER"

THE membership committee is still in the throes of its drive and sends us the following announcement:

"In the Fall of 1927, and early in 1928, the membership committee inaugurated the 'Every Member Get A Member' campaign.

"As a result of the interest of many members and the team work and cooperation of the contact men and leaders in each

class, a growth of over 25% in membership was achieved by the time of the annual meeting last March.

"A new college year has started. It is the logical time for us to renew efforts to increase Yale Engineering Association membership. President Ferguson set the goal for all of us to strive for, when he was elected, namely 2500 members. If each member will make it his obligation to get one member for Yale Engineering Association, in the next few months before the Annual Meeting in the Spring of 1929, we will have carried out our part and obligation to President Ferguson with members to spare. Over 1500 members certainly should be able to increase the membership by more than 1000. Every day or so, we have some contact by letter, telephone or personally with some former classmate or Sheff. man, and we should all make it a point to see that this man is a member of the Yale Engineering Association, or if not to secure his application.

TREND TOWARD HIGH STEAM PRESSURES

(Continued from page 12)

marked. The gasoline and diesel engine became more and more developed for marine, automotive and locomotive use. Quoting from Harper Leech in the *Chicago Tribune:*—"The observation that progress is never in a straight line may soon find striking exemplification on the railroads. Higher boiler pressures may delay the electrification of many miles of railroad lines by making possible a far better steamer." Are we reverting to steam again for generating our power for transportation? It may be so—time will tell.

TRAFFIC REGULATED BY AUTOMATIC CONTROL

(Continued from page 14)

the control resembles the policeman—it has a memory. After a car has passed over the contact and come to rest at the corner waiting for a break in the cross traffic, a switch is operated in the control box which provides for a change in the lights as soon as the break in the traffic occurs.

From the above example it would seem that a car approaching a busy street where there was an absolutely steady stream of traffic would have to wait indefinitely. This, however, is not the case, for after a certain definite period of time the light will change. The light will allow uninterrupted traffic on one street until a car approaches upon the cross street, when after a given period it changes and allows the cross traffic to proceed. The period of time which is allowed to elapse is governed by the control box and may be set to any value at will. The value is determined upon by the traffic commission of the city.

If the light is to be installed upon a state arterial highway, a variation of this system may be introduced. The controls are adjusted so that the light always favors the traffic on the highway unless cars are actually waiting to cross or enter upon it. In this case the lights change just long enough to allow the cross traffic to pass, and then they immediately return to the former position favoring the highway traffic. This constitutes one of the hardest tests facing the automatic control, for traffic on the highway must be allowed to progress with as little interruption as possible, and the control has met it very effectively.

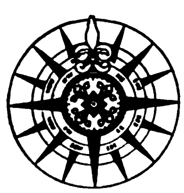
... with their feet
on the ground ---

MEN of vision, yes. But don't overlook the fact that those old Roman road builders and empire builders kept their feet firmly fixed on the ground. They faced the facts squarely. They were demons for detail. They were the world's first great organizers.

Pioneering in the telephone industry is like that. It is a work of vision and of leadership into new fields. But back of it all must be the ability to organize men, money, material and machines.

The telephone executive must coordinate his machine before he can run it. He must understand the possibilities in his organization before he can lead it. That done, his opportunity is empire-wide, vision-broad and ambition-deep.

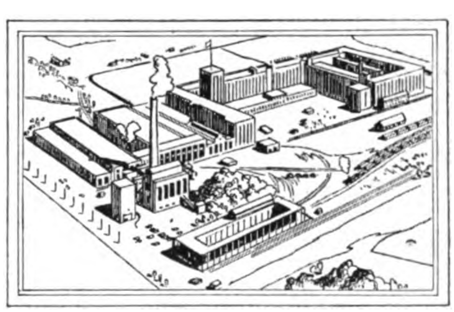
. . . and that holds for making telephones at Western Electric



Western Electric steers a true course.

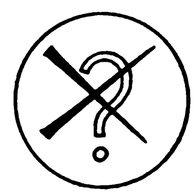
Sure-footed planning applies to telephone manufacture, too. There is never any question about the way this great production job is heading.

The major course is charted years in advance; and the details are worked out carefully day by day, point by point. Does raw material in some far-off country indicate that the supply will continue to come up to requirements? Is there some faster way of testing the two thousand pairs of wire in a cable? Can the laboratory yield a new alloy that will speed up production in the machine shops?



Breaking new ground to keep the nation's telephone-making job "on the ground." The new and growing Kearny plant.

Thus the work of making the nation's telephones goes deep into every science and many arts.



Settling questions is part of the daily job.

Western Electric considers the task as more than one of mustering forces to meet immediate problems. To answer current questions is not enough. New questions must be sought out continually—and answered.

By just such systematic and painstaking preparations Western Electric reflects the spirit of the entire Bell System and fits its work as manufacturer, purchaser and distributor into the broad plan of national telephone service.

BELL SYSTEM

A nation-wide system of 18,500,000 *inter-connecting telephones*

"OUR PIONEERING WORK HAS JUST BEGUN"

CHEMISTRY'S BATTLE WITH BACTERIAL DISEASES

(Continued from page 35)

possibility of all life!" Chemists and physicists are only making a beginning in their efforts to understand the nature and behavior of extremely useful and perfectly operating organic combinations in cellular organisms. These include such constructions as proteins, carbohydrates and fats, and other organic combinations which nature has provided.

A SUMMARY OF THE PRINCIPLE OF RELATIVITY

(Continued from page 9)

and for a long time astrophysicists expressed doubt of the existence of the phenomenon. Only a few months ago, however, St. John published the results of exhaustive measurements carried on at Mt. Wilson observatory which confirm the theory in every detail. Moreover, Adams has found in the dark companion of Sirius a very much larger Einstein shift than that existing in light from the sun, indicating that this star has the almost incredible specific gravity of 53,000.

The Finite Universe.

In attempting further generalization of the relativity theory both Einstein and de Sitter have attributed a slight general curvature to space-time in addition to that existing in the immediate neighborhood of gravitating masses. On de Sitter's theory space time becomes finite though unbounded, in much the same way that the two-dimensional surface of a sphere is finite but yet without limits. While the concept of a finite space-time is still pretty much in the range of speculation, corroborative evidence is found in the predominance of receding over approaching spiral nebulae (the island universes millions of light years distant). On de Sitter's theory, however, we cannot even expect to see the same star in two diametrically opposite directions, for light comes to a stop (relative to us) a quarter of the way around the universe.

Further generalizations of the theory have been made by Weyl, Eddington and Einstein. By making the length of a measuring rod depend upon its past history Weyl is able to include the laws of electromagnetism in his tensor equations. However the relativity principle has not been able to throw much light upon the great puzzle of the present age—the quantum phenomena involved in atomic and molecular structure.

The novel ideas involved in the principle of relativity have been repugnant to many of the elder scientists accustomed all their lives to thinking in terms of the space and time concepts of Newton and Kant. So great, however, have been the triumphs of the theory that it is generally accepted by the younger generation of physicists, and is now often referred to as "classical" in comparison with the more "radical" ideas of the quantum theory. Relativity, it must be remembered, is not in itself a law of nature: it is, in fact, something much more general—a principle to which all laws must conform. If we ask for the law of interaction between electrons and protons inside the atom relativity has no answer to give us, but if we propose a law in our efforts to explain the observed phenomena relativity will tell us whether the suggested law is admissible or not. It offers a criterion which all laws of nature must satisfy.

[AUTHOR'S NOTE: *It may be of interest to observe that the experiment of Michelson referred to in this article has recently been repeated by the same investigator with greatly improved apparatus. The results, which have just been made public, confirm the earlier conclusions in every detail although the precision of the experiment was great enough to detect a velocity 2% of that expected on pre-relativity views.*]

SOME CURRENT POINTS OF VIEW IN NUTRITION

(Continued from page 20)

is so highly purified, cane sugar and white flour, for instance, that without suitable supplements, these staple articles of diet are inadequate for optimal nutrition. A situation in which a free choice or at least a proper supplementing of foods is not the rule may seem remote but one has only to recall that there are individuals who by accident or by force are prevented from exercising instinctive choice, for example, inmates of prisons and asylums, patients in a hospital and soldiers in camp. Moreover, while man has made some clever chance food combinations he also has acquired some bad dietetic habits such as the inordinate use of sweets and of soft foods. There seems, therefore, to be reasonable place for the practical application of proven, sound nutritional principles in our national dietary. The group which already has probably profited more than any other by the discoveries of modern nutritional studies are the babies. The former hazardous period of infancy has been transformed into one of health, of happiness and of easy care largely through the application of nutritional principles originally worked out to a great extent on laboratory animals.

PERSONALITIES

(Continued from page 27)

high standards in such a group. Mr. Crawford's successful handling of this task has added immensely to the prestige of Yale in the eyes of a particularly critical crowd, while through his efforts the examination itself has changed from a test of memory to a paper which demands from the candidate some ability to reason as well as to write.

His dramatic publications have been critical, creative, and editorial. Of his own authorship are *Lovely Peggy*, a play about the famous actress, Peg Woffington, published by the Yale Press in 1911. In the following year *Robin of Sherwood* was produced by the Dramat and published by the Press, while he won the important Addison Porter prize with *Senlac*. In 1915 his *Coviello* was produced at Dartmouth; in 1916 the Press brought out his *Community Drama and Pageantry*. The account of his experiences as author and director of pageants at various times and in various places would make an article by itself, for which there is no room here. He has edited three plays in the *Yale Shakespeare* series, has acted as associate editor of the magazine, *The Drama*, and collaborated with T. H. Dickinson in collecting *Contemporary English and American Plays*, published in 1925 by Macmillan.

This would be a respectable list of publications for a man who had nothing else to do. Professor Crawford, however, has constantly taught a full schedule; has been continually engaged in dramatic productions either with the undergraduates or with the Little Theater; has written innumerable articles for such papers as the *New York Evening Post*, the *Boston Transcript*, the *Christian Science Monitor*, and *The Saturday Review of Literature*—to say nothing of his novel and his latest book—has borne the burden of the Comprehensive English Examinations; has, as Division Officer, acted as guide, philosopher, and friend to many an undergraduate in need of all three; has taught during the summer sessions at Dartmouth (for two years)—and has undoubtedly done a great many other interesting things of which the historian knoweth not. At present he conducts, on the side, as it were, under the auspices of the Department of Education, a course for public school teachers, and has done ex-

PERSONALITY

(*Continued from page 27*)

tension work of a somewhat similar kind for various organizations. It is a rather bewildering list of activities. One is inevitably reminded of the juggler who keeps a dozen Indian clubs spinning at the same time. It would be pleasant to be able to do any one thing as well as Mr. Crawford does them all.

For years he has been collecting old play-bills and pictures of actors and the theater, and has accumulated an incredible number of items (hence those awe-inspiring filing cases). This collection, unique, and of immense value to future students of the drama, will eventually be given to Yale, and, incorporated with the Library's collection.

Far be it from this article, however, to give a picture of Jack Crawford as a Beaver Man. When and how he accomplishes all he does is his great mystery. Apparently he always has time to chat and he is unquestionably an artist at bridge; he is a thoroughly human being and not a machine. Somehow he manages to do all these things and still find time to prepare his recitations—witness the fact that 1926 S. voted him "the most inspiring teacher". And he never seems to be hurried.

If a man may be known by what he does, this confessedly incomplete list of his works may give some impression of Jack Crawford. After all, however, next to meeting him, the best way to ascertain his personality is not to read what is written about him, but to read what he himself has written. His novel, *I Walked in Arden*, is the best single key. It is a simple, straightforward story; there are no frills nor affectations; it is psychologically true but without psycho-analysis (thank Heavens!); it has flashes of rare beauty, and you will find it very moving. And in it, you will find a part, at least, of Jack Crawford,—and that is reward enough.

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THE YALE SCIENTIFIC MAGAZINE

VOL. III JANUARY, 1929 No. 2

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PROFESSOR C. R. LONGWELL

Is Heredity or Environment Paramount
PROFESSOR R. P. ANGIER

Improved Manufacture of Cast Iron Pipe
PROFESSOR ARTHUR PHILLIPS

New Investigations on Tubercle Bacilli
DR. R. J. ANDERSON

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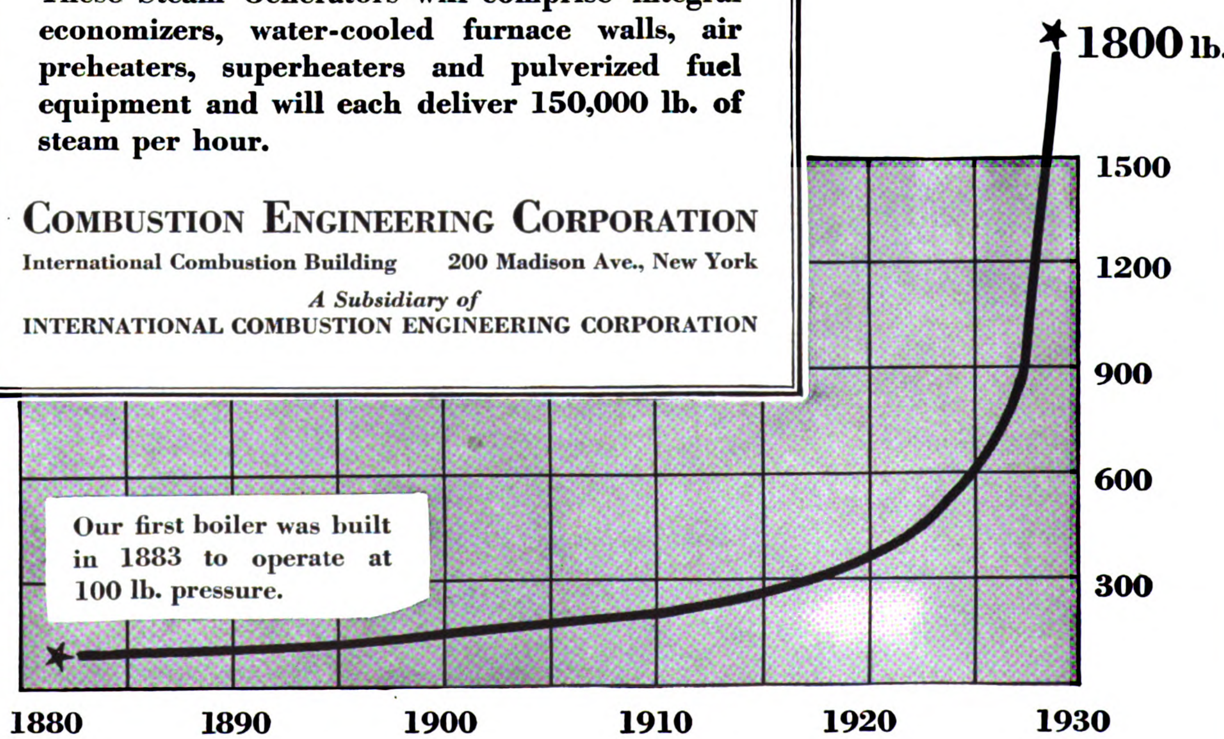

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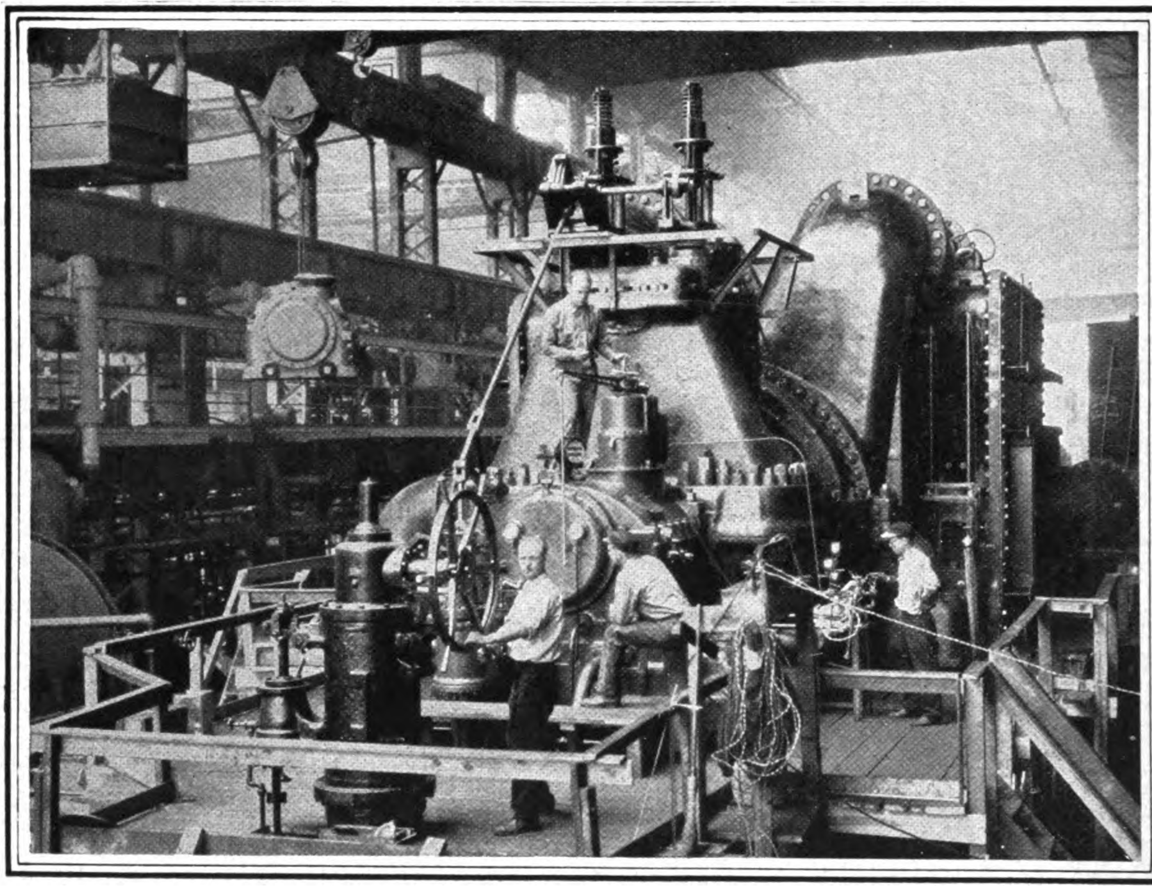

THE YALE SCIENTIFIC MAGAZINE

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Nevada Discloses Secrets of Prehistory

Geologists Explore the Barely Accessible Wastelands of Southern Nevada; the Basin of a Onetime Sea Offers Great Opportunities for Research.

By Professor Chester R. Longwell

VISITORS to the Grand Canyon of Arizona ordinarily reach the scenic chasm either at El Tovar on the south rim or at Bright Angel on the north. In either case the approach leads across the nearly even surface of a high plateau, where only a few scattered volcanic peaks present any contrast to the horizontal lines that dominate the landscape. In the canyon itself the horizontal element is conspicuous. From the flat plateau surface at the outer rim the descent is by a set of gigantic steps, each formed on hardened layers of ancient sea deposits, to the granite gorge that confines Colorado River. In spite of the rugged features about him, the observant visitor sees much that is orderly and simple. The horizontal strata on which he stands can be projected across to the edges of identical strata miles away in the opposite wall. In general outline the history of the canyon is clear. The wide plateau surface has been lifted, with astonishing uniformity, more than a mile above its former level, and the river has cut away hundreds of cubic miles of solid rock to form a valley in the uplifted mass (Fig. 1).

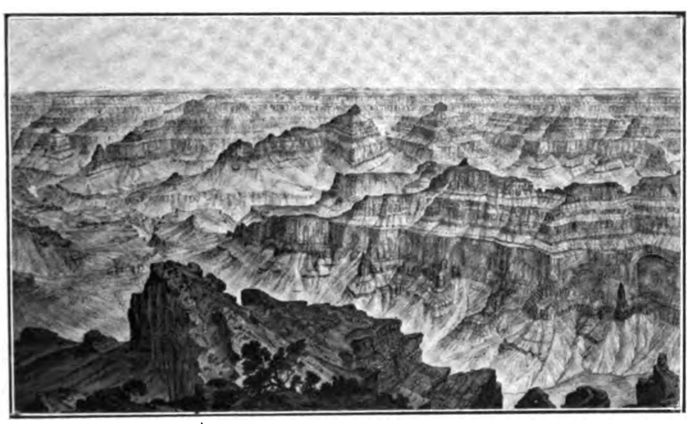


FIG. 1. *Part of the Grand Canyon. The view shows one wall of the canyon and the river at the bottom. Note the horizontal layers of rock and the level plateau surface above the rim.*

Westward from El Tovar the Grand Canyon does not die out gradually to a gorge of mean dimensions. An airplane journey along the winding course of the river would follow a gorge of undiminished grandeur for a hundred and fifty miles. The end comes abruptly at the precipitous cliffs that mark the western limit of the plateau itself (Fig. 2). Crossing the line of cliffs through a high V-shaped portal, the river emerges from the shadow of canyon walls into an open country of low altitude. But the river is not yet entirely free, for the new country is not uniformly low. It is a sierra country, with high north-south ranges separated by wide intermontane plains. The Colorado River cuts directly through two of the ranges before it turns south toward the Gulf of California. The gorge traversed by the river in crossing the Black Mountains is Boulder Canyon, well known as the proposed site of a great dam for irrigation and power projects.

If the airplane journey is continued westward from the mouth of the Grand Canyon it reveals a rugged, desolate expanse stretching 250 miles to the high Sierra Nevada. For the most part the mountains are rocky and barren and the intervening lowlands are desert wastes. Slopes of a few exceptionally high ranges are clothed with dark evergreens, and in some of the valleys small green patches mark scattered oases; but in general the whole landscape is drab and uninviting. West of the Colorado in this region there are no rivers worthy of the name and none of the scanty drainage reaches the sea. The mountains are wasting away slowly, and their debris is heaped about them or spread over the intermontane lowlands. These are the ***basin ranges*** of Nevada and California.

This rugged country, forbidding in its aspect and sparsely inhabited because it is unfruitful, is a geologist's paradise. Unlike the soil-covered surfaces of more humid lands, the ranges of southern Nevada afford continuous sections of the bedrock for direct observation. The Grand Canyon and its tributaries also offer this great advantage for field study; but the region of the basin ranges has been more active geologically than the plateau

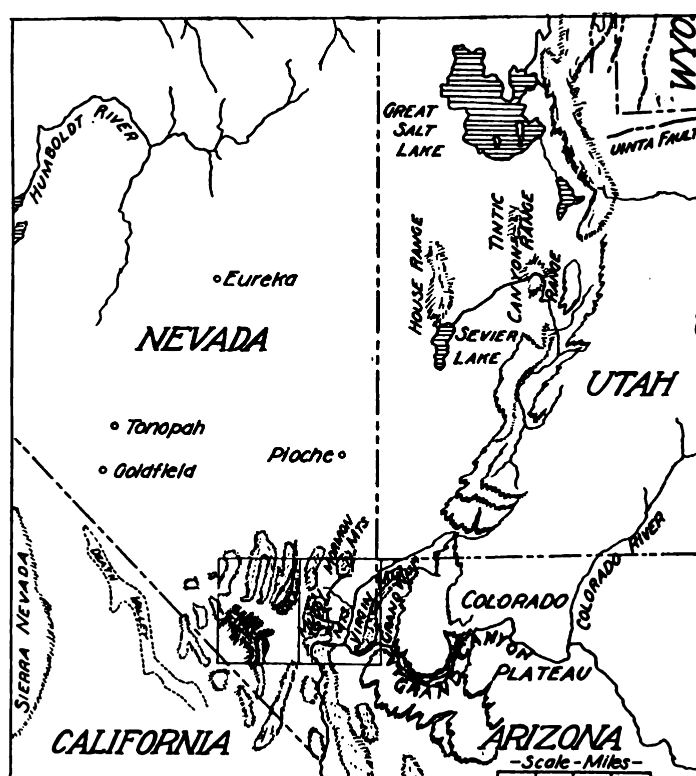


FIG. 2. *Index map. The two rectangles shown in southern Nevada are map areas, each covering nearly 4,000 square miles, Only a few of the basin ranges outside of these areas are shown.*

to the east, and accordingly presents a greater variety of geologic problems. Furthermore mineral wealth of various kinds has been found in many of the ranges, and there is opportunity for

new discoveries. The added fact that parts of Nevada have been especially difficult of access and therefore have remained little known gives considerable zest to exploration in the region.

Method of Work.

Good roads are few in much of the basin-range country, and therefore transportation difficulties present a serious obstacle to work in some of the areas that are most attractive to the geologist. Scarcity of water and distance from settlements increase

FIG. 3. *The author moves camp. Pack animals carry the supplies and camp equipment.*

the difficulty. Fortunately, the modern motor car can go not only on very bad roads but over country where no roads exist. With a sturdy truck that has sufficient clearance a skillful driver can traverse piedmont slopes and canyons where no vehicle has ever been before. Speed is not a requisite; the car becomes essentially a traction engine for transporting supplies to a base of operations. Provided with such equipment a geological party can take necessary food and water to the most remote location and work independently for two weeks or more at a time. But as no car can climb mountain sides the geologist still finds the horse an indispensable auxiliary. Saddle horses are required for much of the work around a base camp, and in surveying the larger ranges it is a great advantage to have a pack train for

FIG. 4 *The floor of Death Valley, California, covered with salt. In the foreground is a rough surface of "pinnacle" salt partly dissolved by rain and darkened by wind-blown dust. The floor of the valley is 250 feet below sea level.*

trips of several days' duration in order to avoid the loss of time involved in returning each night to a central point (Fig. 3). Mining camps and isolated ranches make the most desirable headquarters, but for the most part the geologist must live as a nomad, establishing his camp wherever convenience demands and moving frequently as the work progresses.

Climate and Vegetation.

It is necessary to plan the work with regard to climatic conditions. In summer months the intermontane areas are almost unbearably hot, and field work in the low country at that time of year is inadvisable. Near Colorado River shade temperatures of 115° or even 120° F. are not uncommon in midsummer, and in Death Valley, the lowest and most inhospitable of the basins, a maximum of 137° has been recorded—the high record for the United States. During the same season, however, the adjoining ranges offer a surprising climatic contrast. Above an altitude of 5000 feet conditions for summer work are agreeable. Cold nights are the rule in high mountain valleys, and day temperatures are moderate. In a series of summer records representing several mountain camps the writer found the maximum temperatures above 8500 feet were less than 70°, although on the same days in the adjoining lowlands, at 2000 feet altitude, the thermometer reached 117°. During the fall and winter, however, the valleys and piedmont slopes have delightful weather conditions, and the highlands are unpleasantly cold. From October to April a blanket of snow covers the slopes down to the 6000-foot level, and around the higher peaks it accumulates to considerable depth. It is necessary, therefore, to study the ranges during the summer and reserve the intermontane areas for the cooler months.

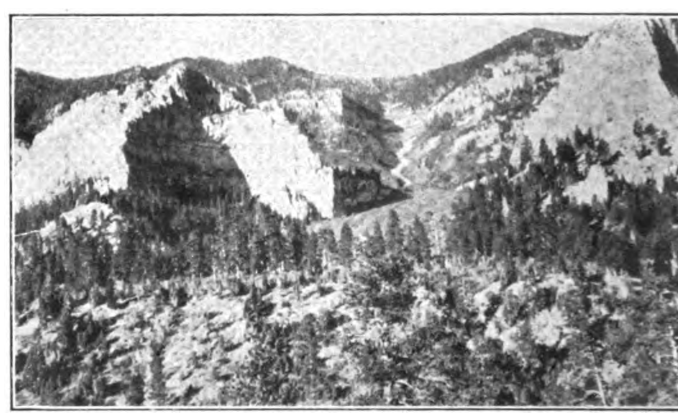


FIG. 5. *The interior of a high range. The large pine and fir trees in the lower ground are at 8,000 feet elevation. The white limestone cliffs are 1,000 feet high. The trees on the high slopes are foxtail pine. The top of the range is at 11,000 feet altitude.*

The high areas receive much more rainfall than the low basins, and this fact, together with differences in temperature according to altitude, determines pretty definite zones of vegetation around the higher ranges. The flat floors of intermontane basins, which at long intervals are resolved into temporary shallow lakes by floods from the slopes, support only scattered desert shrubs. A few of the lowest basins are floored with salt and so are utterly barren (Fig. 4). On piedmont slopes the abundance of vegetation increases generally with altitude, and there is a continuous change upward from one dominant kind of plant to another. At about 3000 feet the dark-green "creosote brush" almost monopolizes the gravelly slopes. At 5000 feet the fantastic "Joshua trees" (tree yuccas) are interspersed with sage, Mormon tea, and other low shrubs. Juniper, which grows at a lower altitude than any other evergreen, appears at about 5500 feet, and somewhat higher up it is joined by the pinyon. Large pine trees are found at 6500 feet, and a thousand feet higher the mountain valleys have a dense growth of yellow pine, fir, aspen, mountain mahog-

any, and other trees (Fig. 5). In the midst of such luxuriant growth it is difficult for one to realize that he is in the midst of a desert; but only a few of the ranges have the height and width to provide these forested valleys. Above 9000 feet the foxtail pine is the predominant tree, and the last scrubby individuals of this form are left behind at 11,500 feet (Fig. 6). Thus the exceptionally high ranges have two tree lines—an upper and a lower.

Geology.

The rocks that make the basin ranges are of many kinds, but most of them belong to the *sedimentary* class; that is, they consist of compacted and cemented mud, sand, and gravel that were spread out on sea floors or on river flood plains during past ages, when the geography of western United States was wholly different from the present. Limestone is the predominant kind of rock in most of the ranges, but shale, sandstone, and conglomerate also are of large importance. Granite and other crystalline rocks form the basement beneath the sedimentary formations. Lava flows and volcanic ash, expelled from volcanoes which were numerous in the region during the latest geologic epochs, cover all the other rocks in some localities.

FIG. 6. *Timber line near the top of a high range. The highest points are nearly 12,000 feet above sea level. The highest scrubby trees are at 11,500 feet. An abundance of marine shells and fossils were found in the layers of limestone and shale.*

Perhaps it is difficult to conceive that the sea once covered a region where high mountains now rise out of a desert waste. Nevertheless there is positive proof that southern Nevada was beneath the sea during long periods. In every range there are large thicknesses of limestone containing an abundance of marine shells and other fossil evidence of ancient sea life. The nature of the rocks themselves bears witness to long-continued marine conditions with fluctuating depths and shifting shorelines. Thus the limestones correspond to the limy deposits now forming on much of the ocean floor, in clear water at some distance from land. Thick shales and sandstones represent old deltas and other near-shore deposits of mud and sand. In some localities typical deltas of this kind lie between limestone strata below and above, indicating temporary shallowing of the seaway and encroachment of the shore zone on areas of deep water, and later recovery by the sea of the lost ground. In this way the old sediments and their fossil forms record the story of the ancient struggle between land and sea, and make it possible to trace shorelines as they existed in many geologic periods.

The stupendous length of time represented by sedimentary rocks in southern Nevada is suggested by the fact that the total thickness of the section is more than six miles. It is known that such deposits accumulate very slowly; and an even greater original thickness of soft sediments would be required to form six miles of compact rock. Two or three practical questions arise in the mind of the inquiring reader. How can sedimentary strata be observed and measured to a depth of several miles? In the high plateau to the east the Grand Canyon exposes considerably more than a mile in vertical section; but surely no canyons are deep enough, and no individual mountains high enough, to

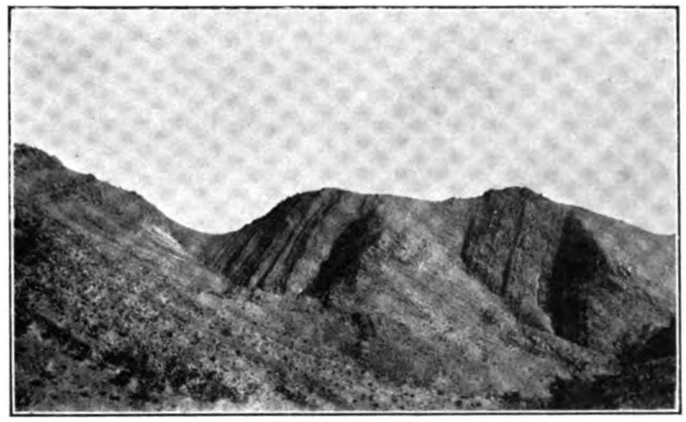


FIG. 7. *Limestone strata, originally horizontal but now tilted at a sharp angle. A thickness of 3,000 feet is shown in this view.*

reveal a similar section five times as thick. Furthermore, if it be granted that six miles of sediments accumulated in the Nevada region, is it to be inferred that the sea was six miles or more in depth at the beginning of the process?

Answer to the first question emphasizes a fundamental difference between the Colorado plateau and the basin ranges. In the plateau the sedimentary layers retain the nearly horizontal attitude in which they were formed (Fig. 1). The plateau represents a wide portion of the Earth's crust that has been lifted as a unit, with little disturbance of its parts. In the basin ranges, on the other hand, the crust was broken into large blocks, many of which were tilted at high angles. The slow work of erosion has

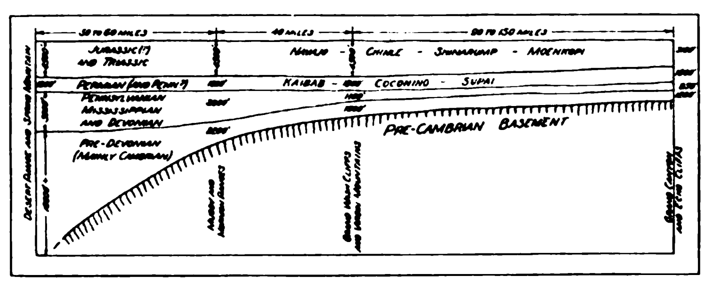


FIG. 8. *Diagrammatic section to show the increase in thickness of sedimentary rocks westward of the Colorado plateau. Diagram represents the rocks before they were broken by mountain-making forces. The vertical scale is greatly exaggerated. Local names of geological formations are given on the diagram.*

beveled these tilted masses and reduced their original height considerably, so that it is now possible to walk across the upturned strata and measure their thickness without the aid of excessively deep canyons or high cliffs (Fig. 7). Thus a single range 10 miles across may reveal the entire thickness of sediments deposited during several geologic periods.

The question as to the depth of the ancient sea is answered emphatically by many features of the sedimentary rocks. Full discussion of this matter would require large space; but the general principle involved may be illustrated briefly. On the upper surfaces of many sandstone layers the forms of ancient

ripple marks are preserved in every detail. Duplicates of these forms may be seen today in the loose sand on a beach, or at the bottom of shallow pools. They are made by rhythmic motion of the water above, and obviously they cannot form below the shallow depth to which wave action extends. Yet in the basin ranges these marks recur, at short intervals, through sections several miles thick. Other clear indications of shallow-water deposition reinforce this testimony. Therefore the water that covered southern Nevada was not deep at any time, and the large total thickness of deposits was made possible by a slow subsidence of the sea floor while the sediments accumulated. This history is indicated in the diagram, Fig. 8. Before submergence began the old granites and other crystalline rocks, known as the *pre-Cambrian basement,* formed a nearly level land surface extending from California across Nevada and

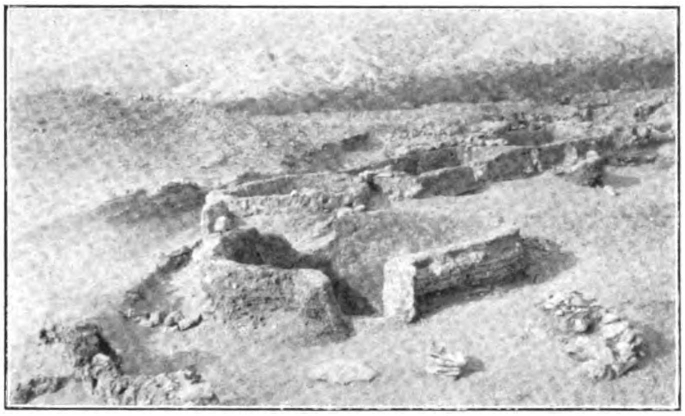


FIG. 9. *Ruins of an old civilization in Nevada. The walls are made of sun-baked mud. They are now excavated from sand dunes which covered and preserved them.*

Arizona. This old land was warped down slowly in the Nevada area, allowing the sea to enter. Sinking progressed in the whole region, but most rapidly in the region of the present basin ranges. Sediments accumulated in the sea, keeping the water shallow. If the diagram were continued northwestward, it would show the pre-Cambrian basement going still lower in that direction, then bending upward in California. An old land, from which much of the sand and mud were derived, persisted in northern California, rising steadily and shedding its debris into the shallow sea.

The order of events outlined above continued until a comparatively late period in geologic history, when it was terminated by a violent revolution. Forces whose exact origin we do not know crumpled and sheared the rocks in a wide belt extending the full length of North and South America. In southern Nevada the thick sedimentary cover, together with the older basement, was broken and telescoped in intricate fashion, and the resulting fragments were turned into various attitudes. The belt of greatest deformation extends to the western edge of the Colorado plateau. This disturbance was not completed abruptly, but continued intermittently during a long period. In parts of Nevada and California movements on some of the great fractures have occurred within historic time, resulting in heavy earthquakes.

During some phases of the disturbance volcanoes were active in the region, piling up thick ash deposits and lava flows. Hot solutions and vapors came up from the depths, depositing gold, silver, lead, zinc, and other metals. The vapors attacked the rocks adjacent to fractures and changed the chemical composition of large masses. There were other important results of the volcanism and related activity. Boron, magnesium and other elements from a deep source saturated the waters of lakes in the intermontane basins, and thick beds of borax, magnesite, and other deposits of commercial value were precipitated. Much of this mineral wealth is yet to be exploited.

Since the first great uplift of the old sea floor Nevada has been a land area, and various kinds of plants and animals have lived in the region, leaving a fossil record in the basin deposits.

(Continued on page 39)

OUR CONTRIBUTORS

¶ *Charles R. Longwell, Associate Professor of Geology, has discussed the geological structure of Nevada in this issue. He is a graduate of the University of Missouri, class of 1915, where he received a M.A. degree. On leaving Missouri, he entered the Graduate School at Yale and received a Ph.D. degree in 1920, becoming Assistant Professor of Geology the same year. He has done extensive field research, and in 1925 was granted a sum of money from the Dana Fund to continue his field studies in Southern Nevada.*

¶ *Rudolph J. Anderson, "Sterling Fellow," whose article "New Investigations on Tubercle Bacilli" appears in this issue, is Professor of Chemistry. He has studied at Tulane University, where he received a B.S. degree in 1906, and at Cornell University, where he received a Ph.D. degree in 1919. He has also studied in Universities in England, Germany, and Sweden and has been Chief of Research in the New York Agricultural Experiment Station, specializing in Biochemistry.*

¶ *Arthur Phillips, '13 S., who has discussed new methods in the manufacture of cast iron in this issue, received a Ph.D. degree in 1913, and later, in 1915 an M.S. degree. He was appointed Assistant Professor in Metallurgy in 1919; and in 1928, he received an appointment as Associate Professor. He is a member of Sigma Xi, of The American Chemical Association, and of Tau Beta Pi.*

¶ *Roswell P. Angier, Professor of Psychology, writes in this issue on "Environment and Heredity". Professor Angier received his A.B. degree at Harvard in 1897, his Ph.D. in 1903, and his honorary A.M. in 1917. He has been a professor since 1917 and was Dean of Freshmen from 1920–1925. He is a member of the American Psychological Association, American Philosophical Association, and Sigma Xi.*

¶ *Lawrence W. Wallace, Mechanical Engineer, has contributed to this issue an article on the scientific method and its influence on the modern age. Mr. Wallace was graduated from the Agricultural and Mechanical College of Texas with the degree of B.S. in 1903. He obtained his M.E. degree at Purdue University in 1912. Mr. Wallace is now the Executive Secretary of the American Engineering Council of Washington, D. C.*

¶ *Dr. Malcolm R. Thorpe, who writes on fossil discoveries in North Branford, received his B.A. from Yale in 1913, and his Ph.D. there three years later. He was a member of the Yale Museum Expedition to Nebraska and Wyoming in 1914. He has also done work for the U. S. Geological Survey in South Dakota and Utah. He is now Curator of Vertebrate Paleontology at the Peabody Museum.*

¶ *Colin K. Lee, who writes on the electric welding of the Sterling Memorial Library, is a graduate of the University of Missouri, B.S. in E.E. 1911 (Sigma Xi). After experience in central station operation, and with the A.E.F., he is now General Engineer with the Westinghouse Electric & Mfg. Co., East Pittsburgh.*

Fossil Discoveries at North Branford

The Finding of Dinosaur Footprints in Sandstone on the Site of the New Haven Water Company's New Dam Leads to Valuable Discoveries.

By Dr. Malcolm R. Thorpe

In October 1926 a dinosaur footprint was found on a block of red sandstone at the site of the new dam of the New Haven Water Company in North Branford, Connecticut, eight and one-half miles east of New Haven. This was of exceedingly great interest because no vertebrate fossils, with one exception, had been found before south of Middlefield, Conn. This one exception is the natural cast of a part of the dermal armor of a primitive crocodile, now on exhibition in the Peabody Museum.

Work Begun Two Years Ago.

More than two years of intermittent field and laboratory work have followed the finding of this single dinosaur track. This work has resulted in collecting and identifying numerous remains of fossil fishes, of vegetation, and of the tracks of seven genera and twelve species of terrestrial vertebrates, consisting of carnivorous dinosaurs, parasuchians (ancient crocodiles) and amphibians, together with tracks of doubtful identity. No bones were found in this locality, and it is a peculiar fact that bones and tracks have never been found in association anywhere in the Triassic formation of the Connecticut Valley.

This reservoir project of the New Haven Water Company is very extensive. The dam was one of the first units constructed. At this site we collected the tracks of two dinosaurs, *Anchisauripus* and *Eubrontes*, the former in the red sandstone and the latter in the gray, while in the intervening black shale strata we found many remains of numerous fish and vegetation. The plants indicated a late Cordaite or early Gymnosperm tree vegetation. No ferns seem to have been present in this area; at least none were indicated by the evidences we were able to discover. The fish ranged in length from about six inches to a little more than twice that. They belong to two genera, *Semionotus* and *Catopterus*, the ancestral forms of the living sturgeons, bowfins and garpikes. No fish were found anywhere else in this area, although the same genera have been collected on the east bank of Lake Saltonstall and in Durham.

Three tunnels have been drilled north of the dam. One, a mile long under Great Hill, is the outlet from the basin. This tunnel cuts through trap rock most of its length, and, of course, no fossils occur in this rock. Another tunnel of the same length through Totoket Mountain is nearing completion, but as it is mostly through trap, no evidences of prehistoric life have so far been observed, although it is now cutting into sandstone and shale strata and may produce fossils before completion.

The longest tunnel, the Sugar Loaf Tunnel, is 13,503 feet long and cuts through sandstone and shale its entire length, and it was from this tunnel that our greatest numbers and variety of tracks were collected. From the ceiling and piles of debris of this tunnel we obtained footprints of seven genera *(Anchisauripus, Eubrontes, Gigandipus, Grallator, Batrachopus, Shepardia* and *Triaenopus)* and twelve species of land forms which inhabited the Valley a hundred million years or more ago.

The collecting was done by means of steel chisels with step ladders for staging, as the tunnel progress had to be maintained without interruption. Many of these tracks were natural casts. The reason for this is that the blasts shattered the shale strata, which was originally mud and soft enough to take a good impression of the footprint. The covering layer of sand filled in the track and made a cast of the actual print, faithful in every detail, and the shock of the blast was absorbed in this heavier layer and did not shatter the lighter, thus leaving a true cast in high relief of the actual print. With one exception all of the tracks observed on the ceiling of this tunnel crossed it at nearly right angles. The direction of this long tunnel is practically east and west; consequently the dinosaurs were travelling north or south. This probably means that they walked up and down beside a stream, which was flowing from the north. All of these tracks were not contemporaneous. They were found extending through more than 100 vertical feet of strata, and if the section at the site of the dam be added, it would more than double the above figure.

The Triassic formation is divided into seven sections, as follows, beginning at the bottom: Lower Series of shales and sandstones; Anterior trap sheet; Anterior shales and sandstones; Main trap sheet; Posterior shales and sandstones; Posterior trap sheet; and the Upper Series of sandstones and shales. Most of our knowledge of the extensive and diverse fauna of this period is derived from the Upper Series. Most of the work at North Branford was done in the Posterior shales and sandstones, about 800 feet thick, and it was from this horizon that all of the fossils came. The site of the dam exposed about 120 feet, and the long tunnel cuts through some 350 feet of the upper part of this subdivision.

In 1927 Professor Lull, the foremost authority on fossil footprints, described the first track found in this locality, and he is in agreement with all identifications made subsequently. Our work was greatly facilitated by the active coöperation of the field men of the C. W. Blakeslee & Son Company, the contractors; by the engineers of Mr. Hill's office, and by the officials of the New Haven Water Company. The following members of the Museum staff assisted in collecting the fossils: Messrs. A. G. Carlson, F. W. Darby, H. Gibb and F. C. Herpich.

The scientific results of this work thus far may be summarized as follows: First, the known range of Triassic footprints in the Connecticut Valley is extended to the south by more than ten miles, and consequently this new locality constitutes the most southerly known limit of the tracks. Second, all of these footprints, fish, and vegetation were collected in the Posterior shales and sandstones, strata from which very few footprints have been recovered heretofore, and in Connecticut, at only one other locality, Middlefield. Third, two sets of tracks represent species new to science. Fourth, of the twelve species found represented, eight are new to the Posterior shales. Fifth, six species have not been found before in Connecticut, and, finally, these tracks prove the ancestry of some of these Connecticut Valley forms older by many thousands of years than previously known.

The Trend Toward Safety in Aviation

New Improvements on Planes and More Efficient Regulation will Result in Increased Safety.

By DONALD F. MACEACHERN,
President of the Yale Aeronautical Society

FIFTEEN years ago, it was a very poor risk to insure aviators or planes, no matter how large the premium, because the probability of a crash was very high, but that was before the days of scientific research in this field. Now there are many aviation insurance companies which deal in no other kind of insurance, and they all seem to be making a very comfortable living without charging excessive rates for most kinds of protection. This change is hardly surprising when one stops to consider such figures as President Coolidge used recently in an address to aeronautical men. He pointed out that in England there were twenty-two people killed and thirty-four seriously injured during the year of the railroads' twenty-fifth anniversary there. At that time the several railroads covered some 3,500,000 miles of territory and carried 10,500 passengers. In marked contrast to this record the Imperial Airways of Great Britain carried 52,000 passengers over 2,500,000 miles in 1927 without injuring or killing a single passenger. Here we have positive evidence of what can be done in aviation if it is properly regulated.

In this country we have not yet attained such a remarkable degree of safety, but as one can see from the figures on the opposite page, we have been giving a good account of ourselves. Over a period of six months—probably the most dangerous months of the year because of danger from frozen radiators, icy fields, and long periods of inactivity of some pilots who do not take a check-hop with a competent instructor before resuming their flying operations—there were only 390 accidents of any kind reported to the Department of Commerce, and all accidents, even minor ones, must be reported to them. Of these, 168 were due to the pilot, through negligence, poor technique, disobedience of orders, or errors in judgment, 94 to miscellaneous reasons, 65 to failure of the power plants, any only 20 to structural failure. It is interesting to note in this connection that of the 390 accidents for the half year, 65 were in planes not licensed by the federal government and 124 of the pilots operating the planes were unlicensed. This means that at least 124 of these accidents should never have happened because these men should not have been in the air. As yet many states have not taken the necessary steps toward proper aviation legislation and have allowed too much leeway to pilots flying in ships licensed only by the state and not by the federal government. For example, right here in the state of Connecticut a pilot with only 100 hours to his credit may give instruction in a state licensed plane while the federal law requires two hundred hours. A tragic result of this laxness happened in California not so long ago. A certain man who had had about four hours of instruction found himself in need of money to finish his course and hung out his shingle as an instructor in the art of aviation. Of course his first pupil was the only one he ever had. They cracked up on the first lesson and both the student and the so called instructor were killed. Perhaps it is just as well that anyone so foolish as to attempt to learn or instruct under those conditions is not around to bother us, but it is unfortunate that there must be victims of such criminal negligence. The incident was not helpful to aviation because the accident appeared in all the newspapers the next day without mentioning the important fact that the instructor was anything but competent.

Improvements in Construction.

There has been a marked trend in the past few years toward greater research in safety of construction, the favorable result of which is shown by the fact that only five percent of the accidents were due to structural failure. Paradoxical as it may seem, the time when there is the greatest danger to and strain on an airplane is when it is on or near the ground. According to figures put out by the Department of Commerce, the impact of a plane in a normal landing is equal to five times the wheel load. That means that a plane like the Fairchild Model 71 would land with a force of more than five tons. The improvement in shock absorbers has made large ships possible and has taken considerable of the strain on the fuselage away, thus cutting down the possibility of an accident due to a breaking fuselage. Along with the development of shock absorbers has gone the technique of placing the wheels farther forward to prevent nosing over on rough fields or when a bad landing has been made, until at present the wheels are even ahead of the leading edge of the wing in most cases. Having thus eliminated the fear of nosing over, the next natural step was the adoption of brakes for the wheels, making it possible to land in small fields more safely, but the drawback of this arrangement was that the tail came off the ground slower and the added weight on the tail-skid dug up the ground in warm weather. However, it was an easy matter to increase the tail surfaces slightly and to put a wheel in place of the skid and equip it with brakes. Add to these features wide-spanned wheels, and we have a plane which has both lateral and longitudinal stability when on the ground and the ship taxies with the ease and handling ability of an automobile.

Since pilots have studied more about how to get out of spins, the fear of going into a stall has somewhat decreased, but if the plane is near the ground when the thing happens, there is practically no hope of making a safe landing. Often an inexperienced pilot, when getting out of a small field gets panicky when he sees a tree ahead of him and goes into a climb that is too steep for the ship that he is flying, and consequently stalls. There have been several methods devised to prevent stalls, but there is still something to be desired in the best of them. There is the Savage-Bramson Anti-Stall gear which aims more at warning the pilot that he is approaching the angle of incidence rather than trying to do anything about the stall itself. An air stream of about ten pounds pressure is directed on the pilot's hand when he approaches a stalling position and thus warns him that it is time to put his stick forward. Of course the success of this method depends entirely on the pilot and therefore is unsatisfactory. The nearest approach to perfection is the manually operated slotted wing, but it also relies on the pilot and that is just what we want to get away from.

Casualties in Student Work.

It will be noticed that sixty-nine accidents occurred in student work. This is the largest percentage due to any one cause

and it shows us that we have a great deal of work to do in this direction. The first step to be taken is the standardization of state aviation laws by taking over the federal laws and enforcing them. That would do away with cases like the one mentioned above in connection with the Connecticut aviation laws.

TABULATION OF ACCIDENTS CIVIL AVIATION PERIOD JANUARY 1st TO JULY 1st, 1928

CAUSE OF ACCIDENT

		Percentage
PERSONNEL		
Pilot	Error of judgment	8.45
	Poor Technique	22.95
	Disobedience of Orders	4.95
	Carelessness or Negligence	6.32
	Miscellaneous	.62
Other Personnel	Supervisory	.35
	Miscellaneous	3.10
MATERIAL		
Power Plant	Fuel System	5.12
	Cooling System	.57
	Ignition System	4.00
	Lubrication System	.13
	Engine Structure	1.29
	Propellers and Accessories	.44
	Engine Control System	
	Miscellaneous	.45
	Undetermined	4.59
Structural	Flight Control System	.85
	Movable Surfaces	.35
	Stabilizing Surfaces	
	Wing, Struts and Bracing	1.09
	Undercarriage	1.64
	Wheels, Tires and Brakes	.19
	Pontoons or boat	.03
	Fuselage, Eng. mount and Fittings	.75
	Tail Skid Assembly	.19
	Miscellaneous	.23
	Undetermined	
Handling Qualities		.44
INSTRUMENTS		
MISCELLANEOUS		
	Weather	10.23
	Darkness	1.28
	Airport and Terrain	8.72
	Other	3.90
UNDETERMINED AND DOUBTFUL		6.78

43.29 Errors of Pilot.
3.45 Due to Other Personnel.
46.74 Total Personnel Causes.
16.59 Power Plant Failures.
5.32 Structural Failures.
.44 Handling Qualities.
22.35 Total Material Failures.
24.13 Due to Miscellaneous Reasons.
24.13 Total Miscellaneous Causes.
6.78 Cause Undetermined.
6.78 Total Undetermined and Doubtful.

100.00% Total

VITAL STATISTICS

	Number of Accidents	
KIND OF FLYING		
Schedule Flying	34	
Student Instruction	69	
Experimental	17	
Miscellaneous	270	390 Accidents
PILOT		
Licensed	195	
Unlicensed	124	
Letter of Authority	71	
Average Age of Pilots	28.6 years	
With Medical Waiver	14	
Without Medical Waiver	264	
Fatal Injury	65	
Severe Injury	63	
Minor Injury	69	
Uninjured	193	
PASSENGER		
Fatal Injury	88	
Severe Injury	70	
Minor Injury	74	
Uninjured	206	
AIRPLANE		
Licensed	165	
Temporary Number	160	
Not Licensed	65	
Completely Demolished	172	
Complete Overhaul	83	
Major Assembly repairs	89	
Minor Repairs	42	
Not Damaged	2	
NATURE OF ACCIDENT		
Class "A" Collision	2	
Class "B" Collision	25	
Class Engine Failure	17	
Class Without Engine Failure	98	
Class Forced Landing	83	
Class Bad Landing	55	
Class Take Off Accident	44	
Class Taxying	10	
Class Fires in the Air	4	
Miscellaneous	41	
Unknown and Doubtful	11	
LIGHTER-THAN-AIR-CRAFT	1	
TOTAL NUMBER OF ACCIDENTS REPORTED	390	

Another well-advised step would be the segregation of student work from the traffic of the ordinary commercial airport. This solution would not be practicable in most parts of New England because our possible ports are too few to permit restricting them to any one kind of flying, but through the West it could be used to good advantage. I have seen too many students who were taking their solo time at Hartford narrowly miss being run down by National Guard planes not to be in accord with this idea. Then, too, there is vast room for improvement in visibility of training ships. The monoplane, of course, is the best ship from this point of view, but it has drawbacks along other lines such as increased wingspread, accompanied by increased space necessary for its storage.

(Continued on page 39)

Is Heredity or Environment Paramount?

A Modern View on the Age-Old Problem of What Determines an Individual's Activities, and Thus His Temperament and Character.

By Professor R. P. Angier

WHAT determines an individual's activities: his rising and going to bed, his food getting, his doings as a social animal, his play—anything behind which there is some dynamic urge? What, consequently, determines his temperament and character? How much is due to heredity, and how much to environment? This is a specific modern formulation of a more general problem that has bothered thinkers ever since men began to speculate, to wit—how much of our *post*-natal experience is *pre*-natally determined? Whether one's original nature, or equipment, is inherited from one's forebears, or fashioned and implanted by God, or derived from some other source—these are merely differently pitched formulations of the underlying query.

Plato, for instance, more than two thousand years ago, stated that much of what a person experiences is merely a reminiscence of what he experienced in a pre-existent state. A parallel of this is found in the Vaiseshika philosophy of early India, the infant's "readiness to suck" being given as a specific instance of the belief that some memory of a previous existence survives into this mortal life. As time wore on the supposition of a state of pre-existence was gradually dropped and philosophers asked, Are there any specific inborn or "innate" powers, or innate ideas, in the human mind? Any original equipment of this sort would, of course, largely determine from the outset what thoughts an individual would have, what things he would do, and what sort of personality he would become. Such innate powers or ideas could be conceived as implanted by God, or simply by nature, or as actual inheritances. The French philosopher Descartes (1596-1650 A.D.) and his school were the classic upholders of the doctrine of innate ideas, while the hard headed and practical Englishman John Locke (1632-1704) and his followers were its outstanding opponents, maintaining—the extremists—that all our ideas and powers are derived from impressions on the five senses of man.

As an exhibit of the tenacity with which this phase of the general problem held on, one need only mention the outburst of controversy in the nineteenth century over the origin of our perceptions of space. Camps were divided into "nativists" and "empiricists." The nativists held fast to the thought that we should not be at all able to perceive the spatial characteristics of objects (size, shape, distance) unless we had some inborn space "perception" or space "ideas" into which the later acquired percepts of physical objects would have to fit. The empiricists were just as incapable, on the other hand, of conceiving what sorts of things these natively given space "ideas" could be; they therefore plumply asserted that our percept, say of the extent and solidity of an object, is merely a synthetic and novel product of the various simple sensations (light, color, touch, pressure, etc.) derived from the object itself—much as water is a synthetic and novel product of hydrogen and oxygen. There is no water previously existent in hydrogen or oxygen; why should there be any spatial quality existent in the simple sensations that yield, when combined, our percept of the size, or extent, of an object?

Particularly since the advent of the doctrine of evolution the whole problem has been more or less removed from the realm of speculation and submitted to a critique based on the methods of natural science. For our present purpose the formulation would run somewhat as follows: how much of what we do and are may be directly accounted for by characteristics actually inherited, and how much by the dictates of environment? The problem is big and controversial, and I can touch on only one phase of it, namely, the problem of human instincts.

Let us grant that the structural make-up of the human body is hereditarily laid down. The bodily organism is, as it were, presented to the environment and limits from the outset what the environment can do with it. The product must be a human being of some sort—neither an amoeba nor an angel. To give heredity such a negative, limiting function is quite different from allotting to it the job of positively developing tendencies or urges which in an executive, dynamic, purposive way march forward to their own fulfillment. Let us grant, further, that environment has little to do with those bodily activities that are not under the direct control of the will—the circulation of the blood, the processes of digestion, of glandular secretions, the contraction or the dilation of the pupil of the eye, etc. These are automatically regulated, alter little, and all hands would admit that they belong to heredity.

But when we come to the so-called voluntary processes, those over which the will does directly have control, we hear a quite different story. These are, of course, the reactions of the striped muscles. It is they that are concerned in the complex reactions that are ordinarily termed instinctive. If, for instance, there is such an instinct as the ancient and honorable "self-preservation," it is obvious that the separate, although complex, *acts* that make for preservation—food getting, seeking shelter and warmth, fighting, flight, raising an alarm, calling for help, and the like—are all performed by different kinds or "patterns," of coordinations of the voluntary muscles. It is partly about the origin of such patterns of activities, the universal *existence* of which none deny, that the camps divide. The "instinctivists" maintain that many of them, at any rate, are laid down by heredity in such wise that they get themselves fulfilled, irrespective of previous experience. Not all, of course; even the most hard-boiled instinctivist would scarcely maintain that heredity determines the casual form of counter-attack, whether by hitting one's assailant with a hammer, shooting him, or squirting vitriol at him. The use of a gun is naturally due to learning, and that is largely a matter of environment. But there is always an instinctive "core" of acts, they say, that is hereditarily determined. If not, if none of the specific patterns of acts are thus determined, is not the term "instinct" meaningless?

Now the non-instinctivists, the "environmentalists," make here as a usual thing one more concession to heredity. They grant that certain relatively simple actions—the so-called "reflexes"—are due directly to heredity. Such are swallowing, grasping movements, crying, coughing, sneezing, simple eye-movements, primitive vocalization, turning the head, and the host of random, aimless movements of arms, legs, and trunk that everyone observes in any healthy, wriggling baby. But, they add, this is all. The definite, complex "patterns" of really useful activities, which enable the individual to cope with the shifting situations that he meets, are developed solely by differ-

ent combinations of the simpler activities above mentioned, and this can occur only by environmental pressure. He who turns the other cheek, as well as he who repels or strikes an assailant starts with the same original random multiplicity of simple muscular coordinations, but in the one case they get patterned into acts of submission and in the other case into acts of offense; and this not because of any underlying, guiding "instinct of submission" or "instinct of aggression." I shall later analyze a typical case to show how the environmentalists get rid of the idea of instinctive guidance. At present I am merely contrasting the positions of the rival factions. Briefly, the pronounced instinctivists assert that there are inherited complex patterns of useful activities; the environmentalists, that all such are simply combinations and re-combinations of a stock of simple—more or less "unit"—acts or reflexes possessed by all healthy youngsters at birth, and that the more complex, useful combinations are acquired or learned to suit environmental needs. The inherited organism has thus, in a further sense, only the negatively limiting rôle described awhile back.

In order to make the position of the instinctivists more concrete and vivid I may record a few samplings of the actual "instincts" that have been attributed by different writers to the ordinary individual. A well known sociologist (L. L. Bernard) has with marvelous industry and patience been through the voluminous literature of the subject and finds that four hundred and twelve authors, in a total of some four hundred and ninety-five books, have listed upwards of three thousand *classes* of instincts and more than ten thousand individual instincts within these classes. *General groups:* acquisitive instincts, aesthetic, aggressive, altruistic, American, social, anti-social, competitive, constructive, creative, egoistic, gregarious, imitative, maternal, play, political, predatory, religious, scientific, self-preservative, submissive, etc. *Specific types:* cleanliness, pity, sacrifice, attack, criminal, homicide, plunder, war, spitting, hoarding, following (mother or hen), petting, concealment, gang-forming, hospitality, experimenting, logical, gambling, combat, adornment, chastity, tree-climbing, spinning, reaching, throwing things about, golf. These two classes take no account of a lot of indefinite exploitations of the term "instinct," which are irrelevant to our purpose, *e.g.*, "Rome *instinctively* created for herself those bonds of Empire" or "A profound *instinct* arms the English against intelligence, which they recognize as the greatest foe to action."

The writer who included golf among the instincts gives us both a smile and a lead. Isn't there perhaps a middle position somewhere between that of the extreme instinctivist who is inclined to include in his list of instincts any ingrained patterns of activity in general vogue, and that of the drastic environmentalist with his denial of the heritability of all but the simplest acts? Isn't it possible that while any specific game (golf, tennis, tiddledywinks, penny-ante) may depend on environment, each and all of them enable one to get out of one's system through specific, acquired activities a more general, truly hereditary urge called the "play-instinct"? In this way one might reduce the number of instincts to a few, granting to environment the development of their specific motor outlets, but saving for heredity the basic tendency. Self-preservation, aggressiveness, hoarding, gregariousness, the maternal urge, etc., might thus be really inborn, although their particular manifestations would be acquired. This is, indeed, essentially the position that the more reasonable instinctivists take. They admit that modern improvements in the details of the care of infants are determined by the stimuli that the mother has received from her physical and social environment and to which she then appropriately reacts—stimuli from words (of instruction or counsel), from books, from example, etc. But, it is said, the stimuli would be of no effect, her reactions would not occur, unless there existed back-stage the inherited urge of maternity in constant control of these acquired, specific acts.

Note, however, that this shifts the problem a bit. We stated early in the discussion that instinctivists maintained that certain complex patterns of *acts* were inherited, which usefully adapt the individual in the absence of previous experience, to certain of his life situations. The stimuli from the environment serve simply to set these off; the environment pushes the button, the inherited patterns do the rest. This is still held to be the case among the lower animals (*e.g.*, the marvelously intricate and precise behavior of ants and bees). In higher animals, and particularly in man, the number, complexity, and precision of such action-patterns admittedly decrease. In proportion, however, to their decrease, more and more is handed over to environment, so that the hereditary factor gets more and more nearly reduced to a bare controlling urge, or tendency, or trend. If we go so far as to grant to heredity none at all of the specific activities that a mother goes through in caring for her infant, then *only* the maternal urge would be left. Similarly the hereditary urge or instinct of play would exist, but *what* is played and *how* it is played, is determined by the exigencies of environment. Thus, many of the instinctivists.

Now the environmentalists are not interested in any nice calculation as to the relative proportions of *urge* and specific *action-patterns* in any given line of human behavior, for they deny bluntly that either urge or action-pattern is instinctive, is due to heredity. Both are acquired. The argument runs somewhat as follows. In any organism (the term generally used for either lower animal or man) there develop certain purely physiological processes which have been given various names as, for instance, "motivating stimuli;" or "appetitions." These appear in consciousness as more or less specifically felt discomforts. The physical nature of some of these appetitions is known. Hunger is one of these. It consists of more or less pronounced rhythmical contractions of the stomach walls brought about, in an empty stomach, by the action of certain acid secretions on the stomach lining. In consciousness these contractions are felt as "hunger." When they become strong and insistent they excite nerves that carry to the brain currents, or impulses, which thence flow over into the nerve-channels leading to the voluntary muscles. These consequently become active; the organism "does something." What it does, and how the doing of it is brought about, is the question at issue.

We have to assume, of course, an organism that has not yet developed definite "habits" by which it gets its food. The inevitable result of the overflow of nervous energy into motor channels arouses then what is termed "aimless," or "sporadic," or "scattered," or "random" acts. The blind, newly born kitten, in its awkward, scratching movements that carry it forward, almost on its belly, guided doubtless by smell, warmth, or sound stimuli, goes through a series of such random acts until its lips come in contact with the nipples of the mother cat; the relatively simple and inherited mechanism of sucking draws milk into the mouth, which acts as a further stimulus to the swallowing mechanism, which places food in the stomach—and the process of sucking and swallowing keeps on until the originally set up contractions of the stomach walls cease or alter their character, until the original hunger pangs are stilled. If the mother cat were not there? One dislikes to develop the picture, but surely the ran-

dom acts of the kitten would grow in extent and intensity until exhaustion set in. But if successful in its gropings the kitten has been started on the formation of its first food-getting habit. The next attempt will be less random, and so on, progressively, until the successful series of acts get stamped in and the unsuccessful or non-essential acts get stamped out. The habit is then completed and relatively automatic. The same sort of formula applies to the lion stalking its prey and to the human infant in its first hunger yells—except that in the latter case the mother is happily there to guide the child's activities and teach it proper habits.

So it is with other bodily stimulating situations or appetitions. Thirst, cold, heat, suffocating air, sex promptings, etc., are all productive of the same general course of reactions—restlessness, random activity of shorter or longer duration which ultimately, if "successful," terminates in some reaction that abolishes or alters the original appetitional condition and brings at least temporary quiescence. Note, however, that in all cases the progress towards success is wholly contingent on *the continued persistence of the appetitional stimuli;* if they lapse, action lapses. Then, of course, the further process of forming crystallized habits, on recurrence of the appetition. These habits themselves are, however, subject to further expansion and development under the promptings of environment and social teaching until whole hierarchies of habits, customs, or *mores* arise, which would not exist if there were not present some basic appetition, or derivatives therefrom, to give the customs point. The whole complex structure of modern arrangements for the growth, manufacture, preparation, and eating of food, including the elaborate manners and conventions connected therewith, could be traced back, deviously to be sure, but none the less certainly, to the original and recurrent hunger contractions of the human stomach. Similarly the various devices for the slaking of thirst, for protection against cold (clothing, houses, furnaces), and the individual and social conventions that have to do with the relations between the sexes. Thus the environmentalists.

What has become of our "instincts"? In the processes described there appear to be no inherited "action patterns" which positively prepare the organism in advance to adapt itself to specific environmental situations. Under the blind guidance of some appetitional stimulus, random "trial and error" behavior ensues—in the absence of previously formed habits—necessitating various combinations and re-combinations of relatively simple reflex units of reaction, until some happy combination of them brings success. Then the follow-up of habits, complex and more complex. The specific action-patterns that positively adapt organisms to specific environmental situations are, along with their resultant desires and purposes, thus the *acquired* end-results, and not the hereditarily *pre-formed* determiners, of activity.

How about the appetitions themselves? Granting that the action-patterns which enable us to satisfy our appetitions are acquired, are not these appetitions the very instinctive, hereditary "urges" or "tendencies" of which instinctivists speak? Yes, if you will, but not at all in the sense that instinctivists have meant. When they speak of the instinct of self-preservation, or food getting, or play, or hoarding, they mean the pre-existence, inheritance, of something positive, which determines in advance, and in the absence of previous experience, a complex adaptive act. Now these appetitions are essentially negative processes. They mean stimuli that involve more or less organic discomfort. In physiological terms they are originally *nocuous* processes, threatening the organism with physical harm if not alleviated —hunger, thirst, cold, heat, bad air, bruises, lack of exercise, etc. They drive the organism to action; if its activities are such as to bring about physiological changes that abolish the persisting, nocuous, appetition-stimuli, those activities get stamped in; so far as its reactions do not serve to dispose of the appetition, they get inhibited, or stamped out. *Positive urges or tendencies, as well as positively adaptive action-patterns, develop subsequent to, and are not given prior to, successful activity.* They are results. We cannot positively desire food until we have had it, nor have a purpose to preserve ourselves until individual habits of defense, etc., that make for self-preservation have been built up in the way described for food getting. Similarly with play, hoarding, or sex-satisfaction, or gregariousness—and a host of other so-called instincts. As one writer remarks, in speaking of gregariousness, man "may well be a social being because he is reared in society, rather than a creator of society because he is (instinctively) a social being." In short, to repeat, the hereditary organism, with its nocuous appetitions—original or derived— limits the nature of the positive action-patterns, or habits, that the environment can develop; and it limits the positive, dynamic urges or desires that can be acquired. It positively determines neither in advance.

What of it? Isn't the upshot the same as if the ten thousand or more "instincts," of which samplings were given on a previous page, actually existed as hereditary, positive causes? The upshot is not the same. There is a world of difference between the two views. The instinctivist's doctrine is necessarily negative and fatalistic in its implications; that of the environmentalist is necessarily positive and hopeful. For if our positive urges and action patterns are acquired in accordance with environmental influences, the action tendencies of the individual—his desires, purposes, temperament, and character can be controlled more to accord with the heart's desire than if they are dominantly foreordained by heredity, over which the individual has no control. The *limits of attainment* are, of course, determined by primary appetitive stimuli, but the specific forms and directions of the complex activities and purposes through which these basic instigators get realized can be controlled by controlling the environmental situations. "What is the use," an instinctivist would say, if true to his faith, "in trying to change so and so; he inherited those traits from his forebears; that's the way he's built, and you can't change him." Or "so and so has always feared lightning, and snakes, and furry animals, and the dark, and has always had a host of dread-provoking superstitions; he was simply born that way." An adequate defense of the fundamental thesis of the environmentalists, so far as human beings are concerned, or cogent reply to objections to it, would fill a large volume. Demonstration of the practical implications of the doctrine— which this paragraph has briefly dealt with—would fill another. But modern psychiatrists, social workers, educationalists, sociologists, are abundantly showing that traits formerly deemed to be instinctive really originate in early unfortunate environmental influences, or "conditionings," and that they can be changed, or quite transformed. Alcoholism used to be labeled as an hereditary trait; no competent medical man thinks so nowadays. The whole list of fears just mentioned were similarly regarded as predetermined. Recent investigation has demonstrated that each and every one of them can be cultivated in a child at will—and then *un*-cultivated. If any are interested in pursuing the subject further let him examine, as samples, "Instinct," by L. L. Bernard, Henry Holt and Co., N. Y., 1924, or "Psychological Care of Infant and Child," by John B. Watson, W. W. Norton & Co., N. Y., 1928.

Improved Manufacture of Cast Iron Pipe

The de Lavaud Centrifugal Process Effects Economies in the Manufacture of a Structurally Superior Pipe.

BY PROFESSOR ARTHUR PHILLIPS

THE manufacture of cast iron pipe by centrifugal processes is undoubtedly the most outstanding improvement in foundry methods of recent years. Although the possibility of casting iron pipe centrifugally has been suggested by the technical and patent literature of the last century, no process meeting the exacting requirements of huge tonnage on a price basis was developed until about ten years ago, when the manufacture of pipe under the de Lavaud patents was perfected. At the present time two plants in this country, the United States Cast Iron Pipe and Foundry Company and the National Cast Iron Pipe Company, are using this process with conspicuous success.

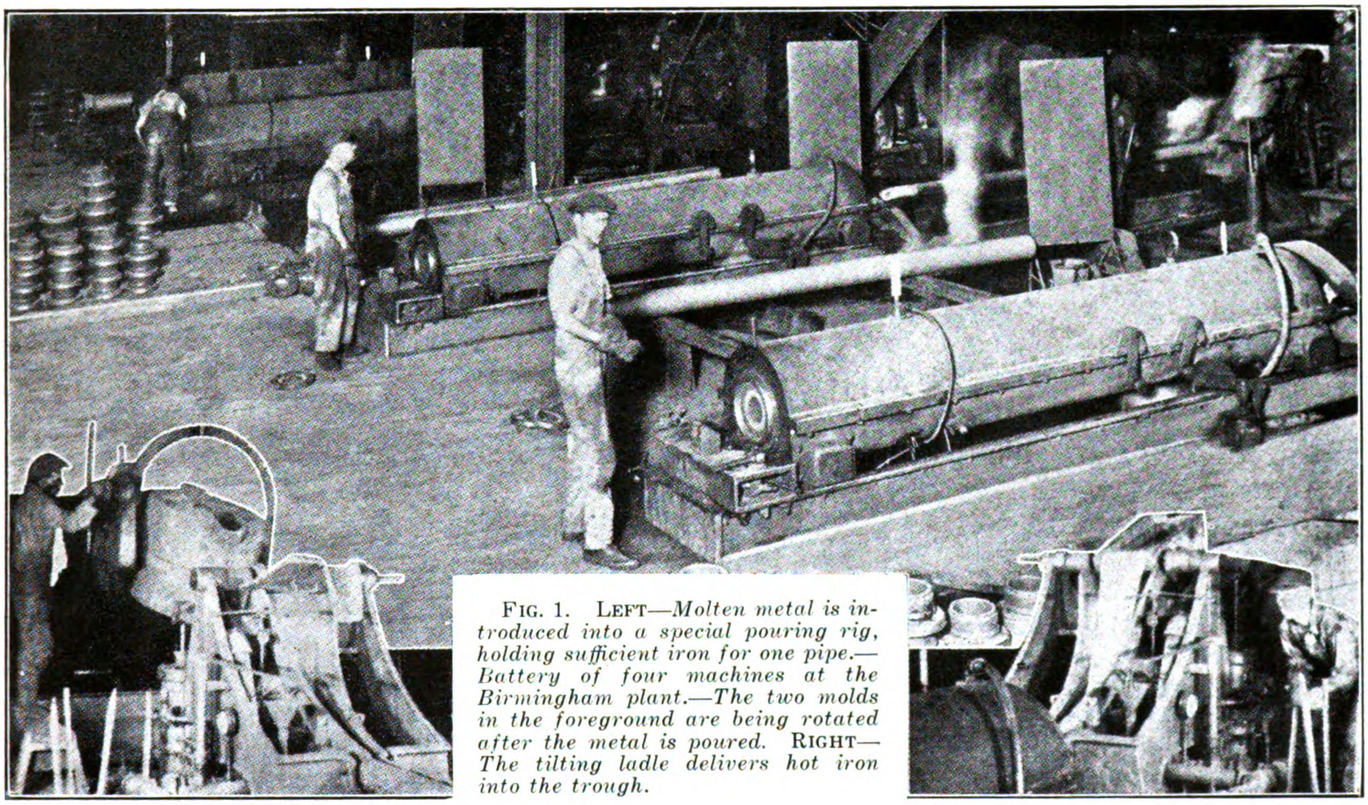


FIG. 1. LEFT—*Molten metal is introduced into a special pouring rig, holding sufficient iron for one pipe.—Battery of four machines at the Birmingham plant.—The two molds in the foreground are being rotated after the metal is poured.* RIGHT—*The tilting ladle delivers hot iron into the trough.*

Briefly stated, by this method the molten cast iron from the cupola is discharged through a spout into a horizontally-rotating steel cylindrical mold, the inside surface of which corresponds to the outside diameter and surface of the pipe. Two distinct motions of the mold come into play during the casting operation. One is that of rotation which forces the metal under the action of centrifugal forces against the inner surface of the mold; the other is a longitudinal movement which results in the even distribution of liquid metal along the length of the mold. In other words, the spout is stationary and the mold travels approximately its own length. The thickness of the pipe may be varied within certain limits by varying the amount of metal poured, together with proper rates of mold motion. A core of suitable shape and dimensions is placed in one end of the mold to form the hollow bell.

The actual pouring and solidification of the metal requires only a few seconds. After the pipe has been removed from the machine by means of a tackle, it is conveyed to a furnace where chill effect caused by the rapid cooling of the metal against the steel mold. The pipes are transferred while hot to the annealing furnaces where they are heated to the proper temperature, after which they are allowed to cool slowly in the exit section of the

(Continued on page 28)

SUMMARY OF STRENGTH PROPERTIES OF DE LAVAUD AND SAND CAST CAST-IRON PIPE

Internal Pressure Tests		*Flexure Test of Pipe*		*Impact Test*	
Bursting Strength, Lbs. per Sq. In.		*Modulus of Rupture, Lbs. per Sq. In.*		*Height of Drop, Ft. Divided by Square of Average Thickness*	
de Lavaud	*Sand Mold*	*de Lavaud*	*Sand Mold*	*de Lavaud*	*Sand Mold*
15,700	13,900	34,500	29,000	14.6	16.7
24,400	16,100	32,200	32,200	12.6	16.6
25,800	14,700	37,000	26,300	14.2	14.0
30,000	13,700	42,700	26,800	11.6	18.2
Av. 24,000	14,600	36,600	28,575	13.2	16.4

The Scientific Method Rules the Age

Science and Engineering in Their Multiple Fields Form the Backbone of Our American Prosperity—The Engineer Is a Vital Factor in the Advancement of Civilization.

By L. W. Wallace,
Executive Secretary, American Engineering Council, Washington: D. C.

THIS civilization has in many directions long since substituted the rule of science for the rule of thumb. Because of this, great masses of people have been elevated and enriched in magnitudes never conceived by those of earlier civilizations. Through pure and applied science the capacity of man has been greatly increased. For these fundamental reasons the scientific method is now recognized as the soundest and most successful method to be applied to any problem of life. The scientific method is nothing more than analysis and synthesis. In attempting any problem the first step is to analyze it, break it up into its component parts, and understand their separate and related functions. With this done apply the principles of synthesis, which is a bringing together of the factors involved, that is, knowing what is to be accomplished, assemble the necessary factors in such relationship as to result in the objective sought. The process sounds easy and in many instances it is easy, provided one has a sufficient knowledge of the peculiarities of the factors involved and the reaction of one upon the other.

Scientific or engineering education consists of learning this technique of making analyses and syntheses and gaining such knowledge of the forces of nature and of matter and the reactions of mankind as to apply the scientific method to them.

Let us now take a short journey into the realm of knowledge and utility, discovered, explored and charted by pure and applied science. This trip will be as spectacular as the prophesies written by Jules Verne, or portrayed in Alice in Wonderland. There is this vital difference however, what we shall see will be actualities, not prophesies.

Science Revolutionizes Agriculture.

Last year the pineapple growers of Hawaii paid $500,000 for paper under which to grow pineapples. The growers raised 30 per cent more pineapples than they otherwise would have, and realized a large saving in labor. For years, the growers had been placing crop refuse between the rows "mulching" is the term used to describe this practice, for the purpose of blanketing the weeds and retarding the evaporation of moisture. This lead to experimentation, to analysis and synthesis, with the result it was found that a tough black paper placed between the rows raised the temperature of the soil, increased the activity of bacteria, moisture remained in the soil until absorbed by the roots of the plants, and the original cultivation of the soil was preserved throughout the growing season.

The Department of Agriculture for four years conducted experiments to determine the advantages of mulched areas. It has found the following increased yields:

White potatoes	73%	Green beans	153%
Cotton	91%	Beets	409%
Sweet potatoes	122%	Carrots	507%
Celery	123%	Cucumbers	512%
Peppers	146%	Sweet corn	691%
Eggplant	150%		

In general, we know of the great work of Burbank in the realm of plant life. We do not, however, have a very clear grasp of the tremendous advances being made by the plant specialists in a very wide field of activity. The work being done foreshadows a marked change in the entire agricultural field. As an example of what has been done, I remind you that a plant has been developed which produces tomatoes upon its branches and potatoes upon its roots.

Great Saving Made in the Handling of Raw Materials.

Skim milk has been one of the bothersome refuses of the farm. "Give it to the pigs" has been the custom. The time is fast approaching when the pigs will be fortunate if they ever see skimmed milk. Probably many of you have purchased handsome and useful vanity and dresser sets without realizing that you were paying for a certain amount of skimmed milk. The handles and backs of such articles are now largely made from the pigs' food supply, skimmed milk.

There is an age-old expression "you cannot make a silk purse from a sow's ear." This is not now true because in the laboratories of A. D. Little, a silk purse has been made from a sow's ear. A fanciful thing to do perhaps but it demonstrates that the jokes of today may become the realities of tomorrow by the application of science.

At the Bogalusa Plant of the Great Southern Lumber Company is a large saw mill refuse burner. A great celebration occurred at this plant sometime ago, at which time this epitaph was placed on the burner:

> "REFUSE BURNER
> Born October 1, 1908—Died July 4, 1924
> Every day during my life of sixteen years, I consumed daily 560 cords of waste material or a total of 2,688,000 cords.
> I cost $25,000 but my fire has destroyed $1,344,000 worth of what was formerly considered waste. The complete utilization of the sawmill refuse in the manufacture of paper has my fire forever extinguished."

The sawdust and other refuse is now literally blown to atoms. The atoms are then collected, compressed and rolled into building boards. Hence, the great eyesore and nuisance pile of the large sawmill is disappearing and the food it thrived upon is going into a useful and an economic commodity.

The refuse pile of the sugar mill up to a few years ago, was just as troublesome as the sawdust pile. But not so today. Celotex is the answer, a building material of such valuable insulating and acoustic properties that the demand is so great sugar mill refuse is being shipped by the boatload from Cuba to the United States to meet the requirements for raw material.

Cellulose, paper and building material are now being made from corn stalks, cotton seed and peanut hulls.

It is fairly possible that farm relief is to come through these and other avenues of scientific application rather than through political discussion and bunkum. I, for one, have more faith in the former than in the latter method.

When hydro-electric development got under way on a large scale in the Northwest, there arose a bitter situation between the fish and electric industries, for the reason that the dams interfered with the salmon going upstream during the spawning season. The situation presented a real problem. Finally, some of the engineers at the University of Washington made some analyses and syntheses. There resulted the installation of elevators at all such dams, which raised and lowered the fish as they desired. This settled the warfare between the two industries and the crowded elevators indicate that the fish appreciate the service.

They also had trouble with the fish getting into the intakes and finally into the turbines. A safety device is now being used to prevent this. It consists of electrodes so suspended as to set up an electric circuit at the intakes. If a fish swims into this circuit, he gets an electric shock which discourages him in continuing further towards the turbines. Hence, this device conserves both the lives of the fish and the turbines.

Remarkable Improvement in Communication and Transportation.

As recently as ten years ago, radio was largely a toy—a thing to play with. Today it is one of the most reliable and useful means of communication and the ultimate has not been reached. Today Mrs. Jones of London and Mrs. Brown of New York, with a radio-telephone combination can converse as satisfactorily as Mrs. Smith and Mrs. O'Hara of Oshkosh.

Furthermore, by means of radio, operators of ships and airplanes may with assurance find their way through fog and storm—hitherto their worst enemies.

The Coast and Geodetic Survey has ships so equipped with radio that they are now able to make soundings at full speed in fog and storm, four or five times faster than without such devices.

By means of specially designed radio and other equipment, prospecting for and discovering minerals and oil is now being accomplished without penetrating the surface of the earth.

The electric man or Telovox is becoming commonplace. An amusing incident occurred in Washington recently. The superintendent of the filtration plant desires to know the stage of the water in the several reservoirs distributed over the city a number of times each day. An electric man was installed at each reservoir. When the superintendent wants to know the depth of water at Reservoir A, he in the usual way phones the electric man there and he gives the depth of the water in feet and inches. By some unknown means, the boys near one of the reservoirs learned of the telephone number of that reservoir. As a result, they kept the electric man so busy answering the phone he almost had nervous prostration. It became necessary to change his telephone number.

The Brooklyn Bridge has been considered somewhat in the light of a world wonder. Today it is becoming a baby in comparison with newer bridges, as the following dimensions show:

	Diameter of Cable (Inches)	*Number of Wires*	*Span (Feet)*
Brooklyn	15½	21,432	1,596
Delaware	30	37,332	1,750
Hudson	36	106,000	3,500

The Holland Vehicular Tunnel under the Hudson River is also of great interest. It is 5,480 feet long and 60 feet below mean low tide. It has two one-way roadways, each twenty feet wide, a narrow sidewalk and head room of 13½ feet. It cost about $50,000,000 and has a capacity of 46,000 automobiles, trucks, horse drawn wagons and vehicles daily. Since the first day of opening, it has been daily used to near or full capacity.

Other agencies to facilitate travel have been greatly developed within the last thirty years. Practically speaking, there were no automobiles, aeroplanes, zeppelins and high speed ships thirty years ago. Today there are a sufficient number of automobiles in the United States to permit every man, woman and child, to take an automobile ride at the same time, provided there were sufficient road and street space.

Man has traveled more than 200 miles per hour upon land and in the air. Tens of thousands of passengers and thousands of tons of mail and express are transported by air each year, all at a cost not greatly exceeding land transport and with a degree of safety comparable with other means of transportation.

The Graf Zeppelin returned to its home port a few weeks ago after a cruise of 10,000 miles. Her return trip was made in 68 hours, at an average speed of 58 miles per hour, for a 4,003 mile trip. At the moment, it is the largest airship ever constructed. However, recently the United States Navy has placed contracts for the construction of two airships, the ZRS-4 and 5, each of which will be larger than the Graf Zeppelin as the following comparison shows:

	Graf Zeppelin	*ZRS-4 and 5*
Nominal gas volume, cubic feet	3,708,000	6,500,000
Length overall	776.2 ft.	785 ft.
Maximum diameter	100.1 ft.	132.9 ft.
Height overall	110.6 ft.	146.5 ft.
Number of engines	5	8
Total horsepower	2,500	4,480
Maximum speed, knots	69	72.8

Rapid advances are also being made in navigation. Within two years it will be possible for one to go from New York to Europe, spend the week-end there and return to New York with only the loss of two or three working days. A model of a ship to be used in this service has been tested in the Navy's Ship Towing Tank in Washington. It gave a speed of 35 knots or about 42 miles per hour. These ships will be operated at an average speed of 33 knots from New York to Queenstown, or four days from port to port. These ships will make between 32 and 37 round trips per year, whereas the fastest ship now in passenger service makes but 14 round trips per year. These new ships will carry airplanes which will take off the ship one or two days before arriving at port, thus making it possible for passengers to make the trip from New York to Queenstown in two or three days.

The U. S. Navy aeroplane carriers, the Lexington and Saratoga, have demonstrated the utility of an airplane-ship hook up. The Saratoga carries 72 planes, 20 of which can take off at one time. The Saratoga went from San Francisco to Honolulu at an average speed of over 30 knots, or about 36 miles per hour.

Literally, radio, fast ships, aeroplanes and zeppelins are making time and space of small consequence in the daily life of most people and making the foreigner your next door neighbor.

Rapid Growth of Production.

The application of the scientific method to the processes of production is revolutionizing industry. Since 1914, the following six basic industries have experienced an increase in productivity as here shown:

	Increase in Productivity in percentage
Automobiles	210
Rubber tires	211
Petroleum refining	77
Cement manufacture	58
Blast furnaces	54
Steel works and rolling mills	60

(Continued on page 38)

New Investigations on Tubercle Bacilli

Work Being Carried On in Sterling Chemistry Laboratory of Great Importance to the Medical World.

By Dr. R. J. Anderson

IT happens not infrequently that a chemical research problem presents several points of interest. Such is especially apt to be the case when the subject under investigation touches the border lines of two or more domains in science. In studying the constituent parts of living cells, for instance, the results may be of importance not only as a direct contribution to chemical science, but bacteriology, biology, immunology, and medicine may also derive benefits.

The investigations conducted in the Sterling Chemistry Laboratory on the chemistry of the tubercle bacillus represent a problem of this kind. The subject is one of peculiar popular interest owing to the wide-spread distribution of tuberculosis among both men and animals. Any fundamental work dealing with the causative factor, namely, the bacillus itself, is hopefully regarded as a step in the right direction toward the eradication or control of the disease.

Scientifically, this work is of importance because it has revealed the existence of several new and interesting compounds in the bacillus. The continuous secretion of these substances, which possess important biological properties, serves to break down the resistance of the host, creating at the same time a favorable condition for the multiplication of the bacillus resulting in an increasing spread of the disease.

These compounds are produced within the living germ, and for our experimental work they are obtained by treating the bacillus with suitable solvents. An intensive study is being made by chemists, biologists, and immunologists to determine as fully as possible the properties of these substances and their relation to the development of tubercular lesions.

All living cells of either plant or animal origin contain proteins, fats, and carbohydrates, but all of these substances vary, more or less, with different species; that is, a general tendency is evident in nature for each species to develop compounds that ar peculiar or distinctive to itself.

It is not surprising, therefore, that a unicellular organism such as the tubercle bacillus produces proteins, fats, and carbohydrates that differ greatly in properties from those of other cells. The first phase of the chemical work on tubercle bacilli at Yale has concerned itself with the isolation of various classes of compounds such as proteins, fats, and carbohydrates contained in the bacillus. After these fractions have been separated each one has been further purified and studied by chemical and biological methods. The progress of the work has been greatly facilitated by the cooperation of biologists who have carefully studied every fraction as it became available and reported upon its biological behavior. In this manner, it has been possible to learn in a short time which products possessed the most important properties, and this information has been of very great value to the chemist.

Heavy Economic Losses.

In the earlier work by Professor Treat B. Johnson and his collaborators, nucleic acids and proteins were studied. As a result of this work it was shown that the water soluble protein present in the bacillus was a highly toxic albumin. This albumin exerts a specific effect on tubercular individuals, causing the so-called allergic reaction with a sharp rise in temperature. It is the active constituent of tuberculin, but tuberculin contains in addition to the albumin a complex mixture of substances the properties of many of which are still unknown. Since thousands of cattle are condemned annually by the tuberculin test, it is evident that an improved and thoroughly standardized tuberculin preparation would be of the greatest economic importance. Experiments and tests are now under way for the production of such an improved tuberculin.

During the past two years the investigations on the tubercle bacilli have dealt mainly with the fat and carbohydrate fractions. The results obtained so far indicate that these components play an extremely important part, not only in the life of the bacillus, but also in the manifestations of tuberculosis.

The bacilli contain an unusually high percentage of fat and the recent researches have demonstrated that a large proportion of this fat consists of a class of compounds known as phosphatides. Biological tests showed that these phosphatides possessed important properties. Further studies have revealed the fact that these unique properties are due to the presence of certain peculiar fatty acids. Experiments conducted by Doctor Sabin and Doctor Doan of the Rockefeller Institute for Medical Research in New York have demonstrated that these acids, when introduced subcutaneously into healthy animals cause the development of typical tubercles. The chemical and physiological properties of these new acids are now being studied, but the work is only in the experimental state, and the acids have not yet received any names. It is evident, however, that these compounds are of peculiar importance in the development of tubercular tissue.

During the past year experiments have been started on the carbohydrate or sugar fractions of the bacillus. The sugars exist not only free, that is, they can be extracted by appropriate solvents directly from the bacillus, but a surprisingly large amount of the sugar occurs in chemical combinations with other compounds. For instance, the fatty substances referred to above as phosphatides yield more than one-third of their weight in the form of sugar after the molecule has been broken up by hydrolysis. The nature or constitution of these sugars is still unknown, but preliminary biological experiments indicate that the sugar fractions possess properties of unusual importance.

The experimental work described above has dealt entirely with the human type of tubercle bacilli. However, the investigation is expanding and will include the avian and bovine bacilli also. It is hoped that comparative studies of this kind will reveal important information. Variation in virulence of such closely related types of pathogenic bacteria may depend upon differences in the chemical compounds that are generated by the living bacilli.

The results of the chemical investigations of the tubercle bacilli so far obtained are promising and are of great interest. The problem is, however, very complex and one meets constantly new and unknown factors.

This brief review illustrates the methods that have been used in the investigation. That a vast amount of work still remains to be done before the problem is solved can not be denied.

(Continued on page 42)

Electric Welding on the Sterling Library

New Bookstack Containing Over a Million Cubic Feet of Space—One Complete Self-Supporting Structure.

By Colin K. Lee

PERSONS whose literary needs are satisfied by a single shelf of books may well gaze with stupefaction on Yale's new bookcase, the Sterling Memorial Library, which will hold four million books. It is in fact the largest single structure of the sort ever built, being exceeded by the bookstacks of only a few libraries, which are the result of successive accretions. It is not amiss to refer to it as a bookcase, for the essence of the building is really the steel bookstack, a self-supporting steel structure, roughly 82 feet wide, 106 feet long and 130 feet high. Though the bookstacks are surrounded and protected from the weather by walls, these walls do not support any weight but their own, and are, in fact, reinforced against wind pressure by the bookstacks within, the ends of whose beams are anchored in the masonry.

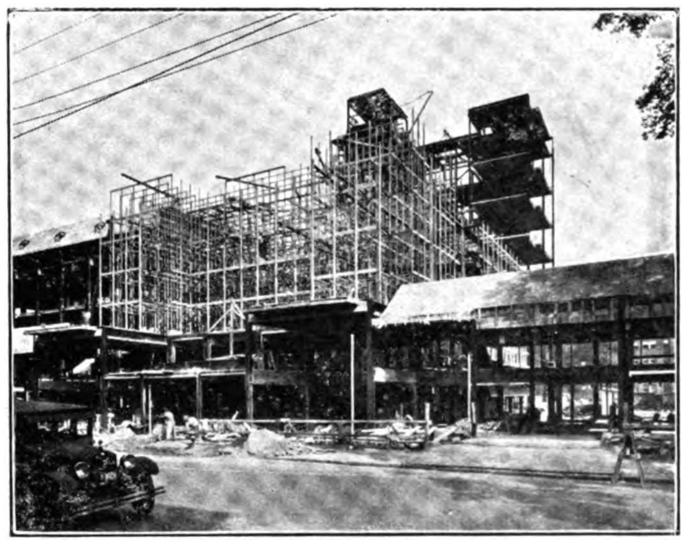
Absence of Noise.

Perhaps the most conspicuous feature of the construction to those dwelling in the neighborhood has been the absence of noise—the steel work has gone up, like the Biblical structure of old, without the sound of a hammer—the 50,000 joints in its steel

Professor Charles F. Scott, head of the electrical engineering department, Sheffield Scientific School, (holding shield) and Gilbert D. Fish, Consulting Engineer of the Westinghouse Electric and Manufacturing Company (at left), inspecting the arc-welding of the eighteen story bookstack for the Yale Memorial Library, which is now in the course of construction for Yale University at New Haven.

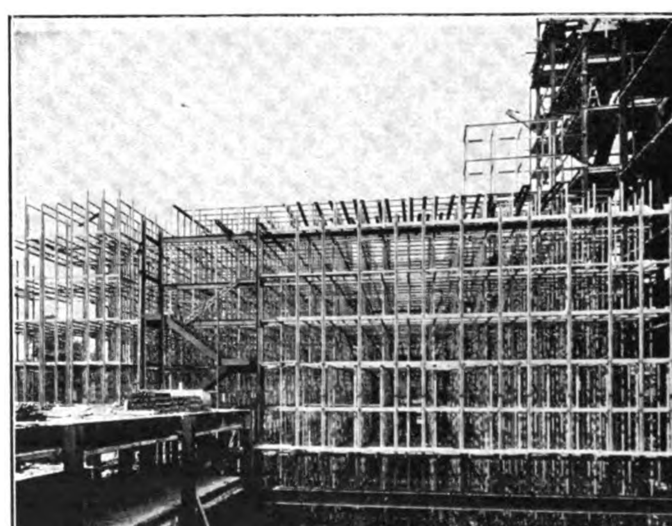
work being electric-welded. Probably the first structure of the sort to be entirely so fabricated, it seems certain that it will not be the last, for the advantages of electric welding are very marked.

An important reason for welding was, of course, to avoid disturbance to the cloistered calm characteristic of contemporary colleges. Circumjacent ears were spared at least 100,000 rivets. Perhaps an even more weighty advantage was the greater stiffness of the electrically welded structure. The most difficult requirement in the framing of tall buildings is often not the simple vertical load of the building and its contents, but adequate stiffness and rigidity against the sidewise bending moments due to high winds. This necessary stiffness against bending stress is, in customary riveted buildings, often had only at considerable expense in money and in awkward encroachments on the useful space.



View of the Bookstacks from York Street.

The Sterling bookstacks are the highest ever built, and thus are exposed to considerable wind pressure. The degree to which the enclosing walls may have to rely upon the steel stack structure in high winds is indeterminate. The strength required against bending due to wind stresses is thus considerable, while the



Snead Standard Stack, Sterling Memorial Library.

(Continued on page 36)

The Eighth Annual Electrical Exhibition

Many Interesting Displays Are Seen at the Exhibition Sponsored by the Student Branch of the American Institute of Electrical Engineers.

By R. B. Whittredge, 1930 S.

THE importance of electricity in modern-day life increases with every new development; transportation, communication, practically all phases of industry are closely related to and more or less dependent upon electricity for their existence. With electricity occupying such a commanding position and the average layman unconversant with the machinery of practical application of that agent which supplies him with so many material comforts and necessities, it was ample provocation that eight years ago brought the Yale Branch of the American Institute of Electrical Engineers, with the cooperation of the Department of Electrical Engineering, to put forward the first annual exhibition of departmental activity. Not only are these exhibitions of interest to the public from a technical point of view, but they present a cross-section of the department and its work, particularly valuable to those, either Freshmen or prospective members of the University, who have not fixed upon a definite course of study. There they find, laid out before them, what the department offers and what it does, a fact-finding opportunity such as is offered by no other department of the University.

Not least important among the advantages of such an exhibition is the cooperation and drawing together of the several otherwise quite separate fractions of the department. It is inevitable that faculty, graduate students, seniors, and juniors working together in the management of such an enterprise should engender a feeling of departmental unity and solidarity that is extremely profitable.

This year's exhibition, held in Dunham Laboratory of Electrical Engineering on December 14 and 15, was arranged by a committee composed of A. F. Metzger, '29 S., Chairman; R. W. Miner, '29 S.; J. R. Sutherland, '29 S.; J. T. Daley, '29 S. ;and A. T. Sinks, '29 S.; with Professors Charles F. Scott and A. E. Knowlton acting in advisory capacity.

The Arrangement of Exhibits.

On the main floor the heavier exhibits were grouped. Here was located the miniature power station, which carried on, in a limited fashion, all the procedure common to such stations in commercial practice. All the apparatus necessary to control this plant in its action was arranged on a switchboard, thus making its operation a direct counterpart of that of the larger commercial station. An interesting set-up of industrial control apparatus showed the application of contactors in automatic machine switching and control. By means of this apparatus the remote control of machinery was demonstrated. During the exhibition demonstrations of undergraduate laboratory work were presented. These consisted of tests upon the various types of direct current machines by the juniors and upon alternating current machines by the seniors. The pieces of apparatus not in use were labeled, thus enabling visitors to inspect the laboratory at will.

Among the exhibits on the main floor were the oscillograph set-ups. Three types of oscillographs were exhibited: a projection model, a photographing, and a portable model. All types were received with great interest by the visitors, who were thus furnished with visible evidence of the current and voltage relations in alternating current circuits.

On the balcony an example of the new type of electric furnace, developed for the heat treatment of tool steel by Professor W. B. Hall of the Department of Electrical Engineering, was in operation. Visitors received a vivid impression of the intense heat developed by the flow of the heavy current through the molten lavite, and the ease with which it heated metal pieces was well demonstrated. Near the furnace was located a group of experiments demonstrating the various magnetic effects. A large electromagnet attracted small iron articles from a considerable distance. The effect of induced current was shown by the copper ring which was thrown off of a large magnet when the circuit through the magnet was closed.

Another recent development, the Electromatic vehicle-operated traffic dispatching system invented and first experimentally operated in Dunham Laboratory by Harry A. Haugh, Jr., '20 S., was on exhibition. A full sized traffic light was operated from a miniature street intersection in accordance with the movements of miniature vehicles. As a contrast a set-up of apparatus such as was originally used for the experimental model was shown, presenting a vastly different appearance from the present business-like box which houses the controls.

On the third floor was located an exhibit of stage and industrial lighting. The various effects which may be obtained from the various colors and lights were brought out, while the carbon and mercury arc lights used in industrial lighting were shown together with the neon-filled advertising signs.

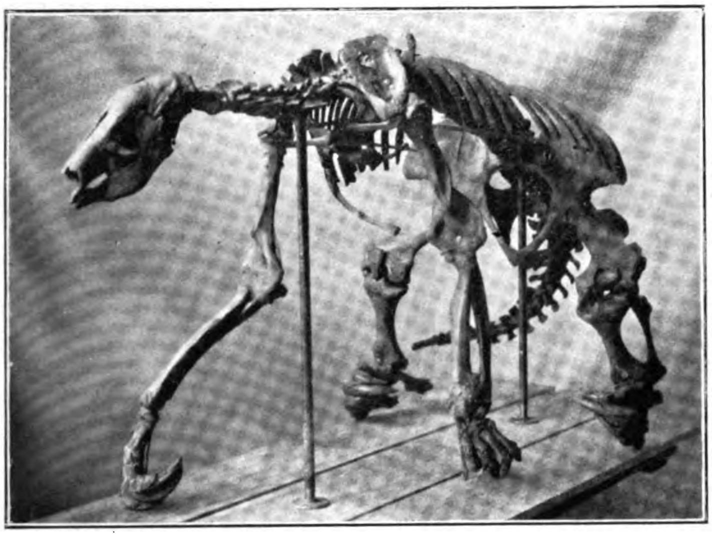
On the fourth floor was located amateur radio station 1JS, which offered to send messages gratis to all parts of the world by means of the A.R.R.L. network. More than fifty messages were filed and cleared. An exhibition of electric radios and reproducing instruments was to be seen at the rear of this floor. In the communications laboratory was located a section of a modern automatic telephone exchange. The visitors evinced great interest in the working of the complicated mechanism which selects the correct number dialed and then rings the corresponding telephone.

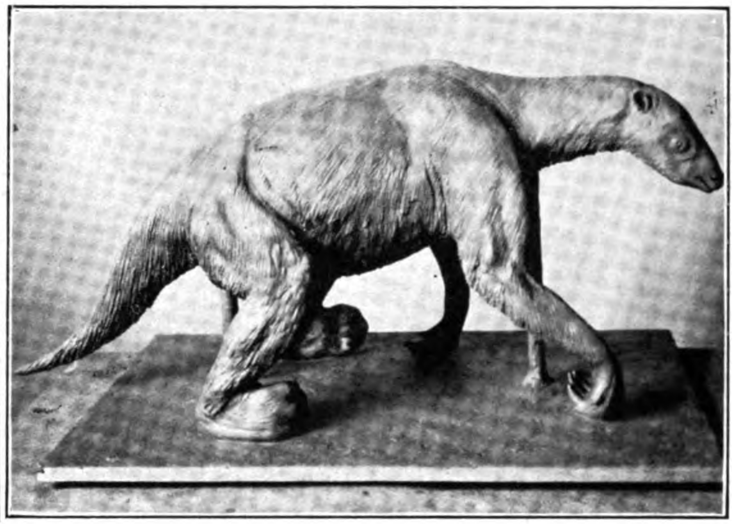
The High-Tension Display.

The most spectacular demonstrations were to be found in the High Tension Laboratory which adjoins Dunham Laboratory. Break-down tests of insulators were conducted by means of a one hundred and fifty K.V.A. transformer. The corona effects which accompany the break-down present a spectacular sight. A large Tesla coil illustrated the effects of high frequency currents.

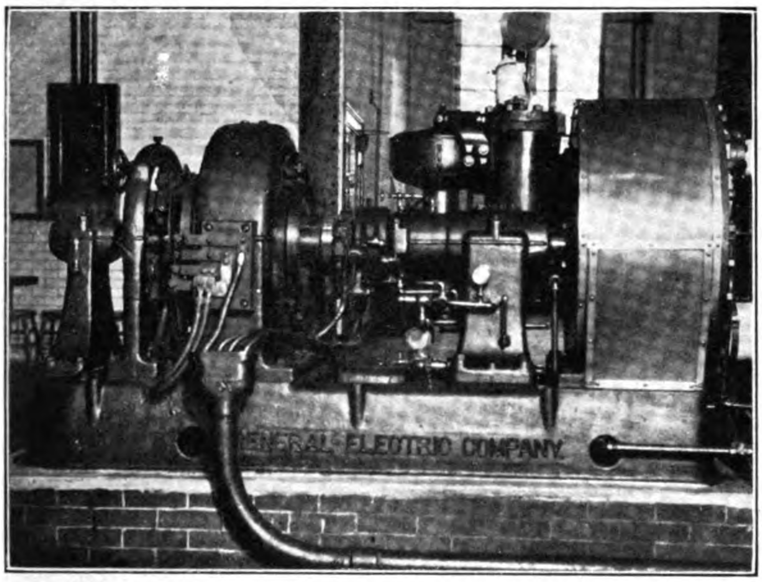
On the opening night speeches were broadcast from station WDRC. The arrangements were made through the courtesy of F. M. Doolittle, '15 S., who is the owner of the station. The program included addresses by Dean Warren, Professor Scott, Professor Turner, and Mr. H. A. Haugh. A large audience witnessed the broadcasting from the lecture room.

The attendance at the exhibition was good, and the faculty and students feel that the exhibition was successful in accomplishing its purpose.

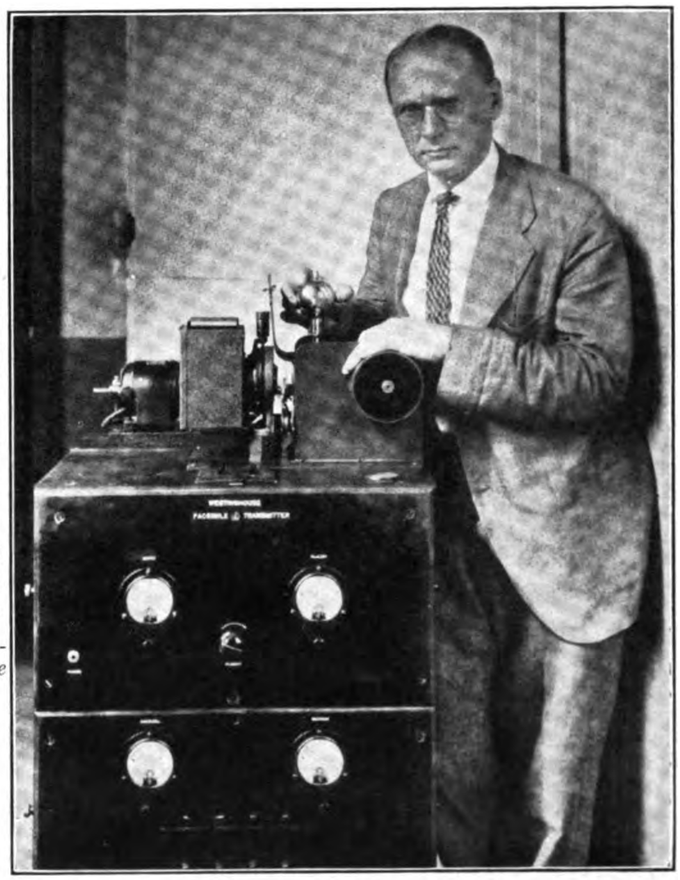




ABOVE.—*Skeleton and reconstruction of prehistoric sloth whose well-preserved body was discovered in Dona Ana County, New Mexico, and is now the property of the Peabody Museum at Yale University. This animal lived between 500,000 and 1,000,000 years ago and was very much like the anteater of today except for its size, which was over eight feet from the tip of the tail to the point of the nose. This discovery is one of the few cases where not only all of the bones, but also most of the flesh has been preserved.*

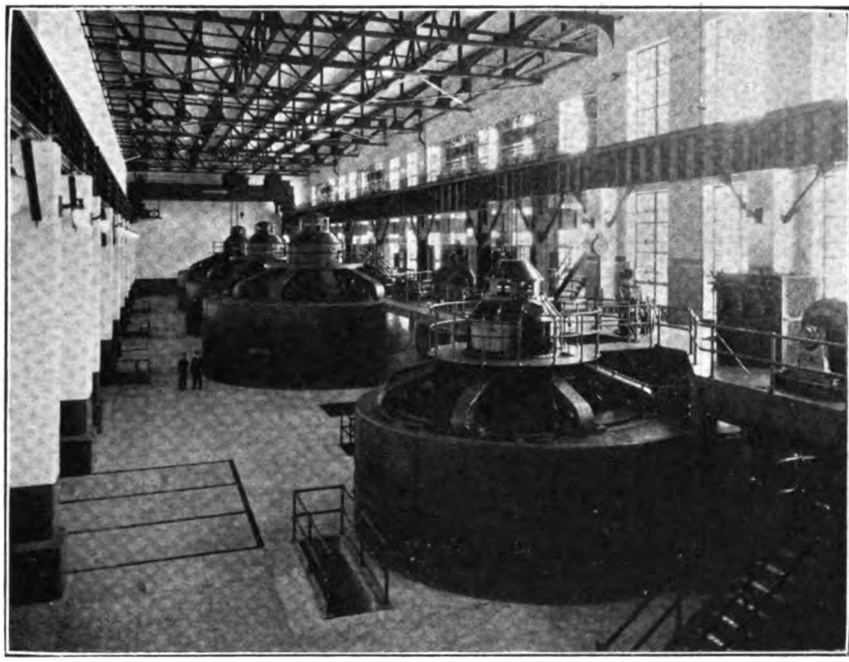


ABOVE.—*Small turbo-generator set in the Mason Laboratory of Mechanical Engineering used for the determination of steam turbine characteristics and efficiencies.*

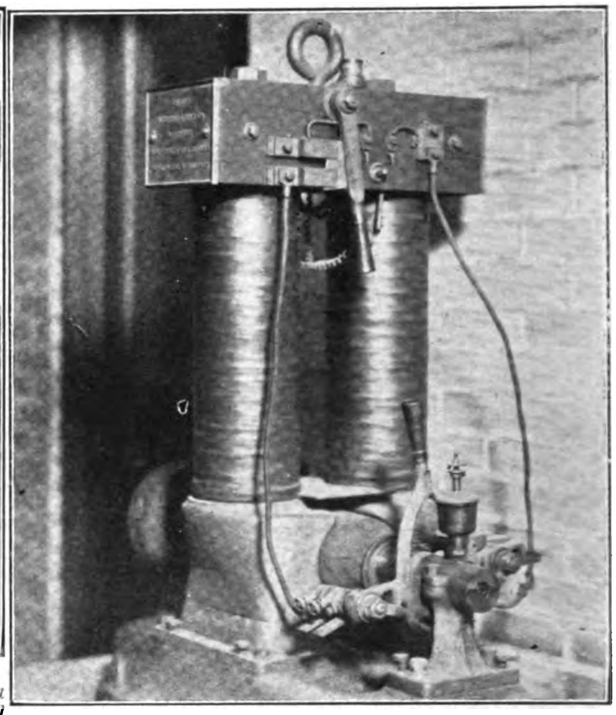


ABOVE.—*Dr. V. Z. Zworykin of the Westinghouse Research Laboratories, with his new transmitter which sends pictures and printed or written matter through space. The new apparatus is much more simple than former types, requiring no trained operators, and is much faster. It is capable of transmitting 630 words a minute.*

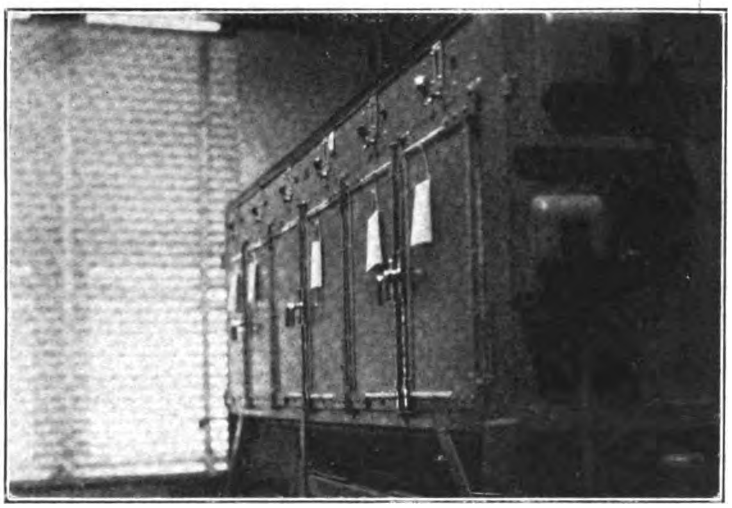
LEFT.—*The new laboratories of the Yale School of Medicine, as seen from Cedar Street. The section fronting on Cedar Street is the Brady Memorial Laboratory; at right angles to this section, parallel to Congress Avenue is Lauder Hall. Parallel to the Brady section is the Farnam Memorial Building, of which only the south end is seen in the picture.*



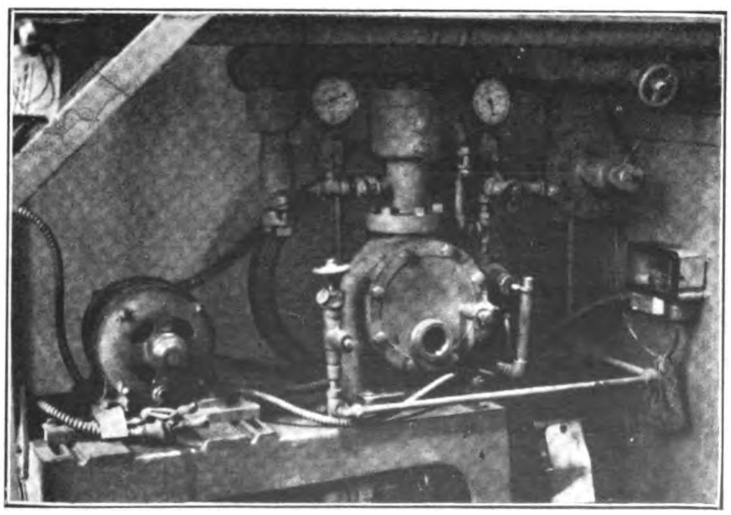
ABOVE.—*The large generating station on the American side at Niagara Falls. The three generators in the background are the largest water-wheel driven electric machines in the world. Each is rated at 70,000 horsepower. These machines are 98.7% efficient. (Compare with the generator at the right, which is 72% efficient.)*

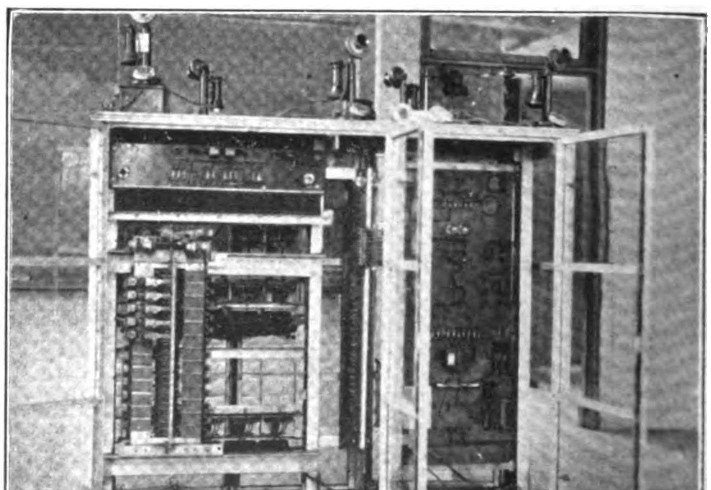


ABOVE.—*Edison generator built about 1884. This was the largest machine built at that time and was rated at 25 "lamps" or about 1½ horsepower.*

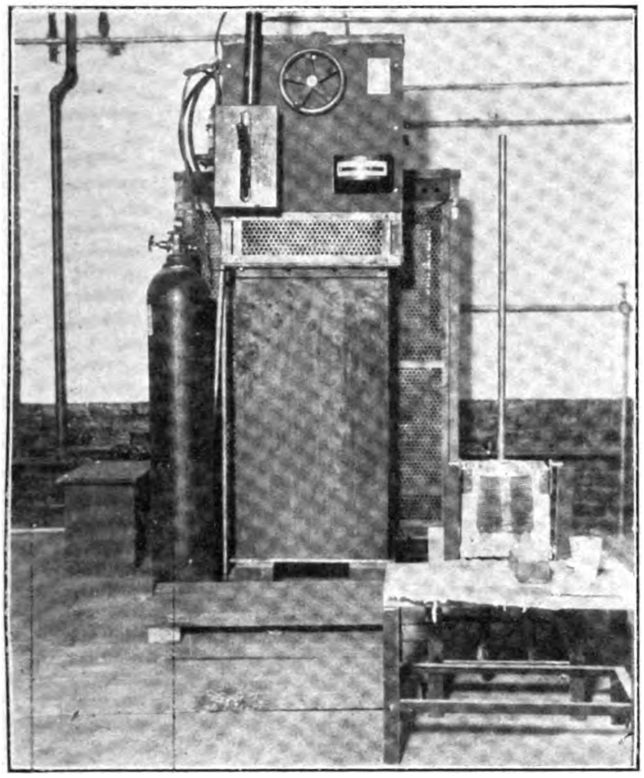


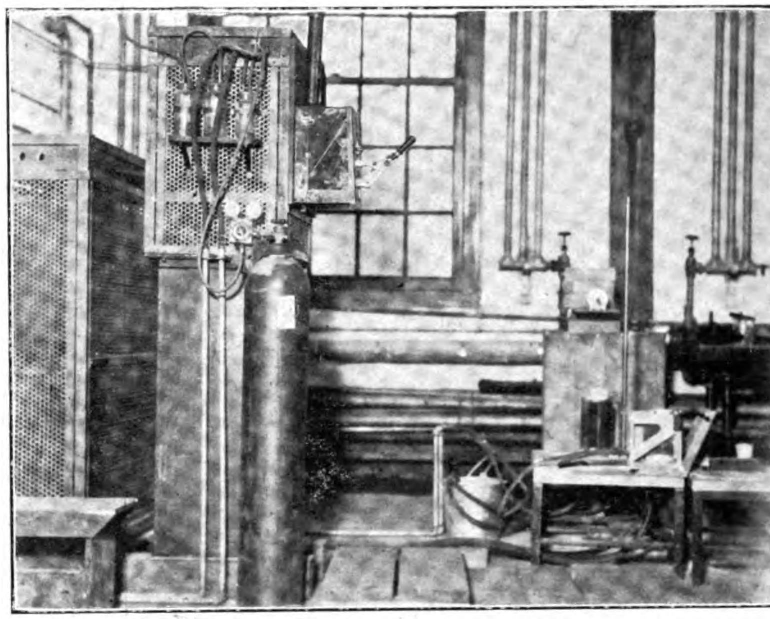
LEFT.—*The new constant temperature machine recently installed in Osbourne Biological Laboratory. It provides constant temperatures for the growth of bacterial cultures, etc. There are six different compartments, each adjustable without reference to any other with an accuracy of 5° C. to a temperature varying between —5° and 60° C. The lower view shows the refrigerating plant of the machine.*



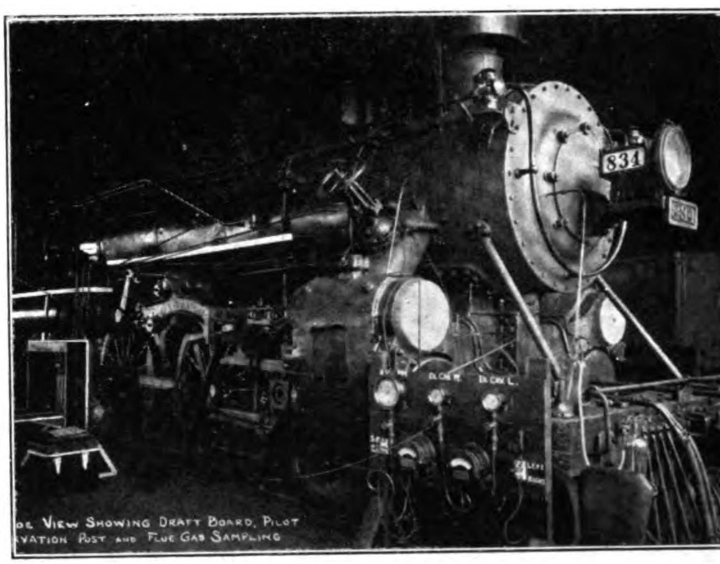


ABOVE.—*Section of automatic telephone exchange in the communication department of the Dunham Laboratory of Electrical Engineering. This switchboard automatically establishes communication between any two of the dial telephones seen on top of it.*



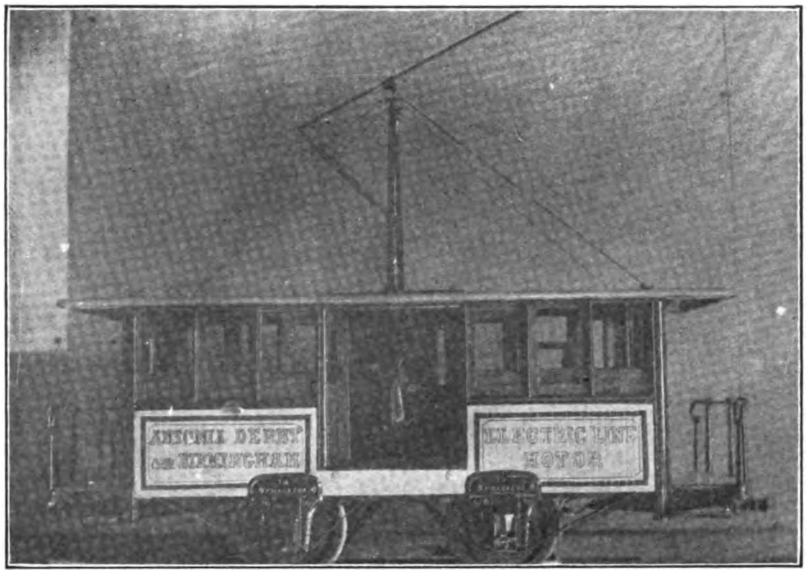


ABOVE AND LEFT.—*A new type of Ajax Northrup high frequency induction furnace. In this furnace the copper coil shown in the foreground at the left acts as a primary while the charge itself acts as secondary. A temperature of 2800 degrees F. is attainable in fifteen minutes. Single crystals of copper, silver, and gold have been made by flowing molten metal through the hot zone.*



RIGHT.—*This engine on the New York, New Haven and Hartford Railroad is being tested to determine the efficiency of its boiler. This view shows the draft board, pilot observation post and the flue gas sampling device.*

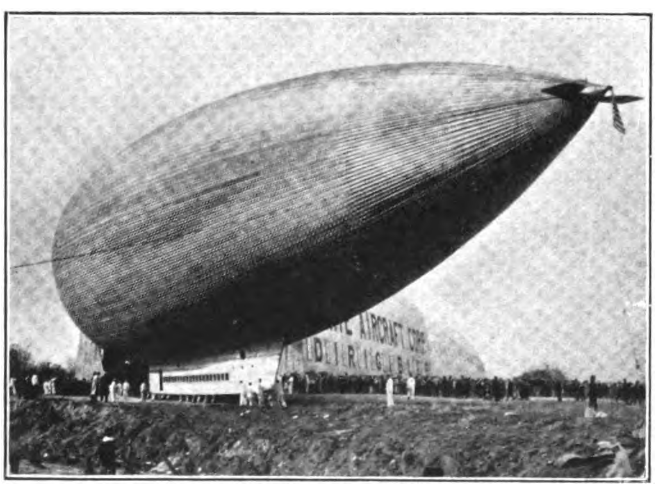
BELOW.—*Fourteen men testing the strength of hollow and convex plywood wings of America's first all stream line plane, designed by M. C. Tunison. It is a low-wing monoplane and has made 200 miles per hour. It is made of ply-wood, has a wing spread of 35 feet, ascended 1,000 feet the first minute of its initial flight, and made a smooth landing at 40 miles per hour. It has no struts. This craft is in the $2,500 class.*

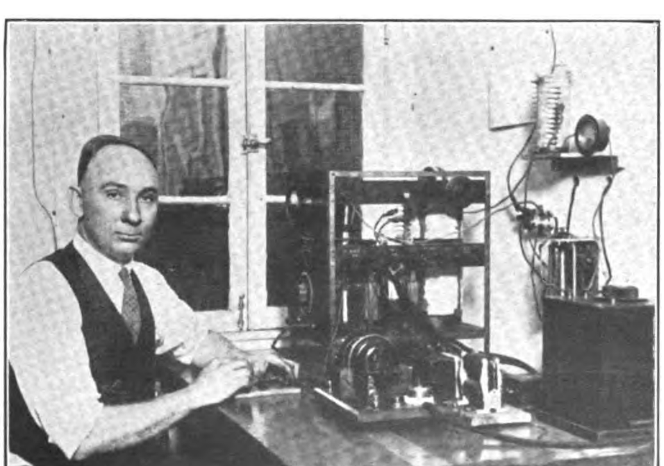


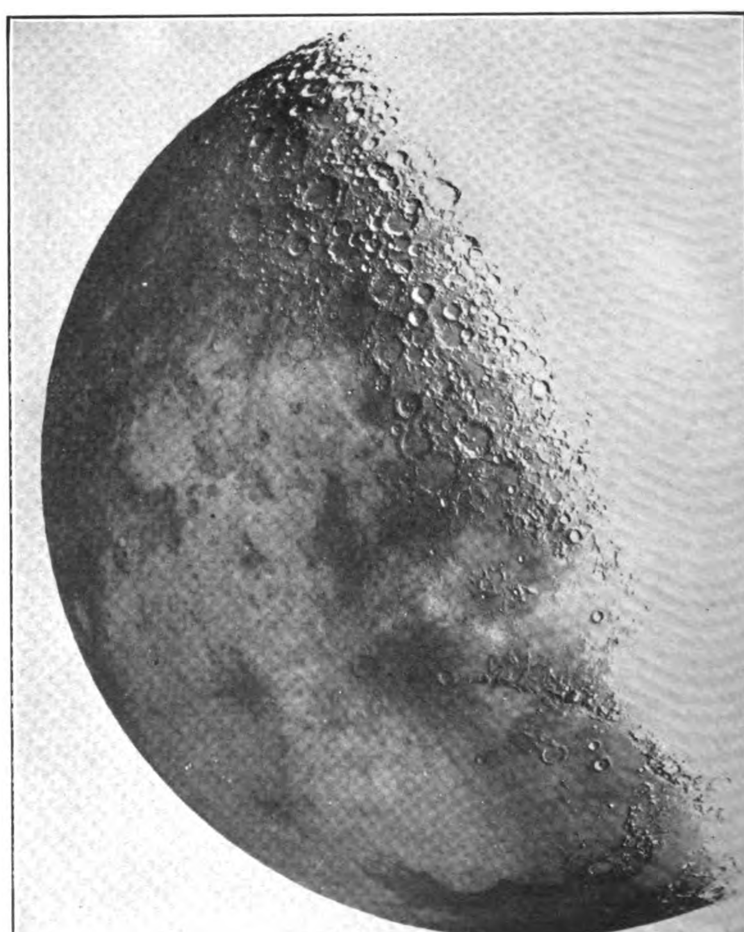
Above.—*Model of locomotive used for the hauling of freight in Ansonia and Derby beginning 1888. The length of the car was 18 feet. This was probably the first hauling of this kind by an electric locomotive.*

Right.—*Pioneer electric car put into service in Meriden in 1888. Note similarity to freight locomotive to the left except for double wire and over-running trolley.*

Below.—*A striking view of the first all-metal dirigible, steam-driven "City of Glendale," out of its hanger for the first time. It was turned around for the completion of the installation of the "blower" propeller and to test its buoyancy.*







Above.—*Photograph of the moon taken at the southern station of the Yale Observatory at Johannesburg, South Africa. The exposure time was only 1/5 second. The telescope is a very rapid one and the air at Johannesburg is extraordinarily transparent.*

Left.—*A radio marker beacon, to be installed on the airways giving flyers an accurate check of the distance from the beacon point, has been developed by the Bureau of Standards at Washington.*

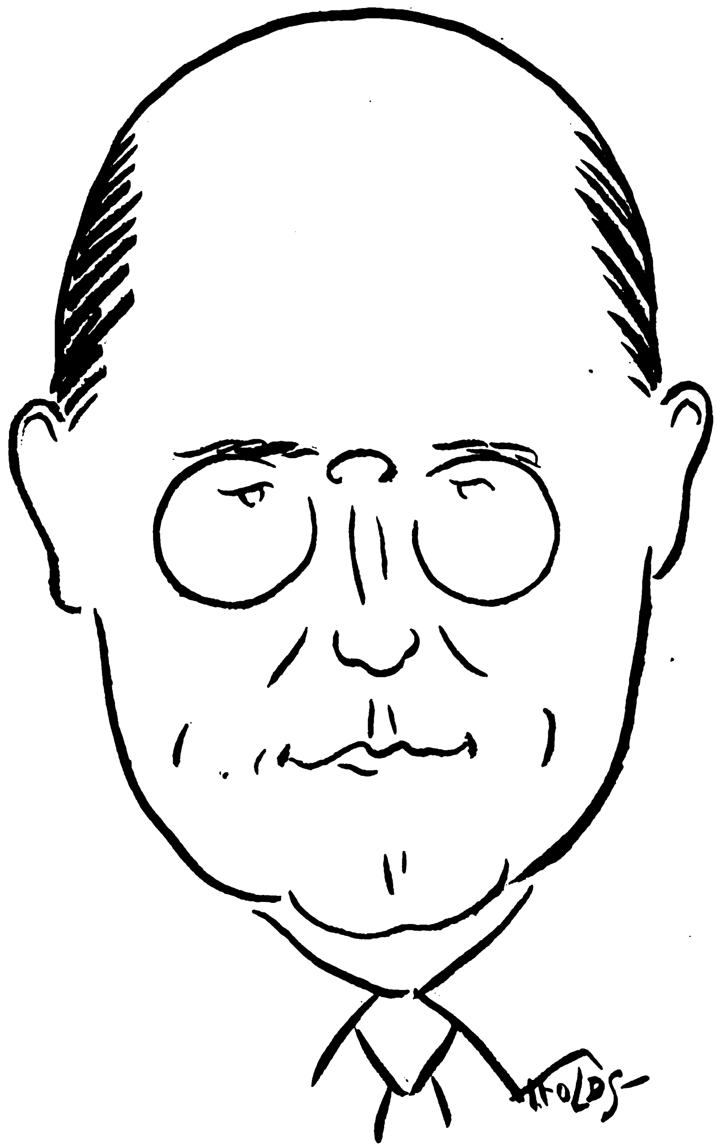
P·E·R·S·O·N·A·L·I·T·I·E·S

LOOMIS HAVEMEYER.

> YALE UNIVERSITY
> SHEFFIELD SCIENTIFIC SCHOOL
> Registrar's Office
> No. 1, Sheffield Hall, New Haven, Connecticut.
> Office Hours, 9 a. m. to 1 p. m.
> Dear Sir:
> Please call at this office at your earliest opportunity.
> Yours truly,
> LOOMIS HAVEMEYER
> *Registrar of the Sheffield Scientific School*

THE Sheff sophomore to whom the official summons is delivered for the first time by the hand of Dan the messenger hastens to obey with dread forebodings as to his fate at the hands of the unknown arbiter. Had he but known, there was no need for fear.

Even the office of the Registrar creates from the first a reassuring atmosphere. Instead of the small, dingy place of his imagination, a room cluttered up with a mass of books, papers and records and inhabited by a heartless ogre, the student finds a bright sunny office suggesting that of a business firm. It is quiet and well organized, with a few industrious clerks, and an inner room for personal conferences, and presided over by a pleasant and very human person, Loomis Havemeyer.



Once the student makes himself known, the matter at hand is quickly adjusted. Whether it be some scholastic warning, or a personal notification of the penalty to be incurred for some infringement of the rules, or merely a request for information, the attitude of the Registrar is one of friendliness and understanding. From the time of their first visit most Sheff men come to feel that the office is not a hostile place to be shunned, but one in which a spirit of cooperation is dominant and where they are always welcome to discuss their troubles and problems. Faculty members who have occasion to come in contact with the Sheff office also experience the same feeling of cooperation, and are perhaps better able to appreciate the executive and administrative ability of the man who directs the efficient machinery of the office.

The position of Registrar, however, is but one of Dr. Havemeyer's activities in the Sheffield Scientific School. Stand near the door of Kirtland Hall when the classes in Social Evolution or Economic Geography are making their noisy exit, and listen to the arguments regarding this point or that which Professor Havemeyer has just made. No man who provokes such lengthy discussions and debates among his students can be else but a good teacher, and Loomis Havemeyer ranks high among the good teachers of Yale. Year after year men who have had his courses come back to listen again to his scholarly lectures or to discuss questions which have come up. Returning graduates speak with feeling of the memories of his courses which they retain long after they have left the institution.

To be either a successful administrator or a brilliant teacher would be enough to warrant admission to the Sheffield Hall of Fame, but Loomis Havemeyer possesses a third qualification,—his intimate understanding and appreciation of student activities and problems. Unlike most men, who shed their undergraduate interests upon their graduation, unless it be in connection with athletics, Dr. Havemeyer has continued to maintain a lively interest in the students themselves and their daily life. His association with the members of the Aurelian Honor Society, of which he is graduate secretary, the Cloister, and groups of undergraduates in his own home have given him an insight into student life and thoughts which is quite unique and which contributes materially to his success in his official capacities. A Registrar who is able to interpret faculty opinions sympathetically to the undergraduates and at the same time present the student viewpoint to the faculty with equal accuracy is a distinct asset to any institution.

Loomis Havemeyer was born in Rye, N. Y., June 7, 1886, the son of Charles William and Julia Ida (Loomis) Havemeyer. He prepared for college at the Hill School and entered Sheff in 1907 as a member of the Select Course, receiving his Ph.B. degree in 1910. As an undergraduate he took an active part in the affairs of the Dramatic Association and the Sheffield Y. M. C. A., and served as one of the class deacons. After graduation he continued his studies in the field of anthropology in the Yale Graduate School, receiving an A.M. in 1912 and his Ph.D. in 1915, presenting a dissertation on "The Drama of Savage Peoples." In 1912 he was appointed an instructor and assigned to the Sheff faculty. In 1920 he was made Registrar and in 1925 received his promotion to Assistant Professor of Anthropology. Profes-

(Continued on page 35)

IMPROVED MANUFACTURE OF CAST IRON PIPE

(Continued from page 17)

furnace. They are rotated during their travel through the furnace; by this method, they are uniformly annealed with no distortion of the pipe.

The essential parts of the casting machine are the steel mold together with the driving equipment and the pouring mechanism. The mold is made of an alloy steel which must be highly resistant to the attack of the molten metal. A water jacket, through which water circulates, prevents overheating. Originally a Pelton water wheel propelled the mold; more recently, another type of driving unit has been adopted. Each machine has a pouring apparatus consisting of a tilting ladle, a cast iron spillway and a refractory-lined trough which feeds metal direct to

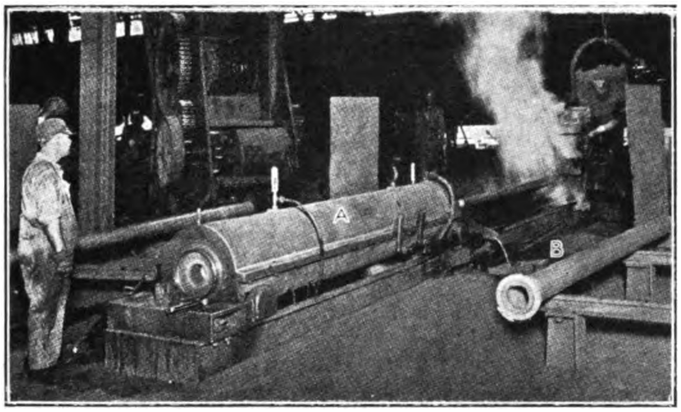


FIG. 2. *The mould is rotated as the metal solidifies.*

the spout at the end of the trough. The evolution of this pouring mechanism has been largely responsible for the success of the process. It is hardly necessary to state that the rate of pouring and the two motions of the mold must be synchronized in order to obtain good pipe.

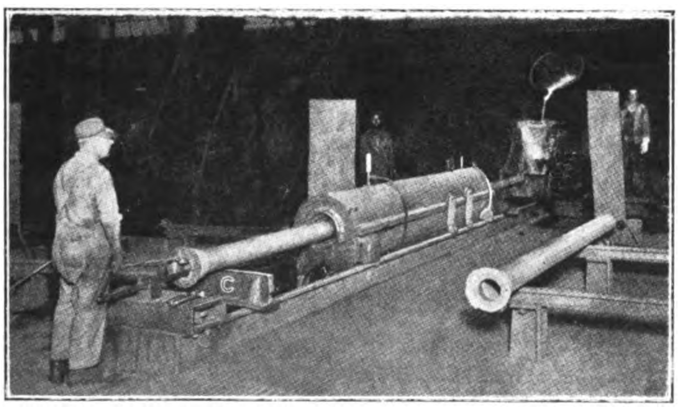


FIG. 3. *Pipe being removed from the mould.*

Some of the important strength properties of the de Lavaud product are summarized in comparison with similar tests on sand-cast pipe in the accompanying table.
Additional data regarding the properties of de Lavaud pipe may be found in the American Society for Testing Materials, Volume 26, 1926.

The manufacture of cast iron pipe by the de Lavaud process has many advantages, both from the standpoint of process and product. Some of these may be enumerated briefly: (1) High strength properties, (2) thinner wall required because of the superior strength values, (3) no central core required, (4) low scrap loss, (5) saving in foundry space, (6) produces a sound, "close-grained" iron, (7) both inner and outer surfaces are

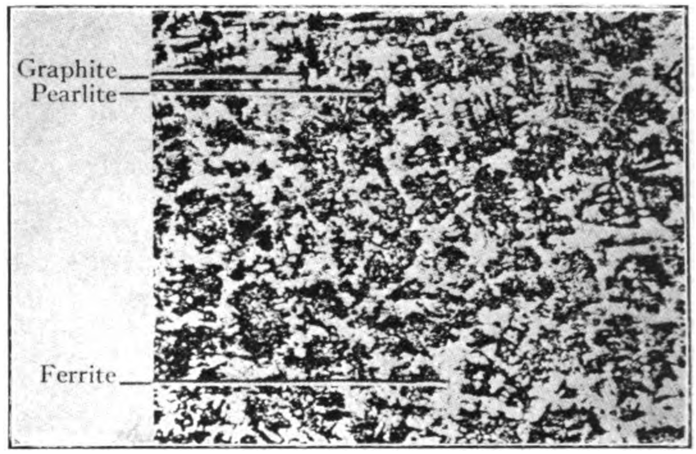


FIG. 4. *De Lavaud Pipe (Center of wall). Magnification 100 times.*

smooth and free of surface defects, (8) the walls are concentric and of uniform thickness through the length.

The microstructures of the de Lavaud pipe and the ordinary sand cast pipe differ in several respects, the most important of which is in respect to the condition of the graphite (carbon).

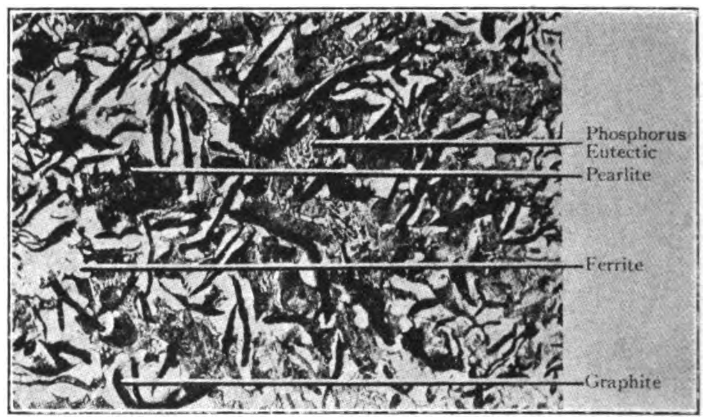


FIG. 5. *Sand-Cast Pipe (Center of wall). Magnification 100 times.*

In the de Lavaud pipe, the graphite areas are relatively small and do not break up the continuity of the mass; in the sand cast pipe, the continuity of the iron is broken up by the long flakes of coarse graphite. It is well known that the shape and distribution of the graphite particles influence to a considerable extent the physical and mechanical properties of cast iron. Typical micrographs of the de Lavaud and sand cast pipe are reproduced in Figures 4 and 5 respectively.

A CORRECTION

In the Pictorial Section of the November, 1928, issue of the YALE SCIENTIFIC MAGAZINE appeared a picture of an early locomotive known as the "Atlantic." The date 1812 in the caption is erroneous, as it should read 1832.

BOOK REVIEWS

Henry Ford—The Man, the Worker, the Citizen. By G. J. DeRoulhac Hamilton. Published by Henry Holt and Co., New York, 1927.

The author attributes the origin of the book to his personal curiosity, interest and admiration of Mr. Ford, crystallized by his realization of a popular demand for the story of his life and his achievements. It is an entertaining and readable story. One gains from it a distinct impression that admiration was by no means the least of the impulses urging the author to his task. In spite of its popular story-book style, the book includes a wealth of detailed information from which the discriminating reader may gain much of value. So much of Mr. Ford's life and achievement had to do with the technique of manufacturing and industrial development that the "popular story" style is hardly as convincing here as when dealing with the more "human interest" portions of the subject. Even in the latter, however, the author appears to wander rather far afield, as for instance, by using two pages to develop the thesis that "Nature too was absorbing" to Henry, as a boy on the Michigan farm. A sentence or two picturing the field and wood creatures which contribute in a large measure to every farmer boy's early impressions might not be amiss, but to subdivide specifically and catalogue the probable doings of the "cheerful, chattering chickadees . . . the nuthatches too . . . the robins, the bluebirds," etc. until testimony and tribute has been paid to 18 other kinds of birds, and two kinds of frogs becomes a little monotonous.

Boyhood experiences and early impressions are rather tediously overemphasized by the author to account for the characteristic individualism and paternalism of Mr. Ford in his subsequent industrial and public relations. The author gives a vivid impression of Mr. Ford's early handicaps which developed courage, resourcefulness and determination to work out his own ideas in his own way.

The origin and growth of the Ford industries is told with much wealth of personal reminiscence—always of Mr. Ford, there being but little more than the mention by name of those associated with him. It is easy to read if one is not oppressed by hero worship. A very considerable amount of information regarding the Ford plants is given without tiresome statistics or detail.

The last chapter on "Henry Ford, the Man" sums up his personality, and philosophy, his daily routine, and his habits of thought and action. His own words and those of his friends are freely quoted. While the book is gossipy and somewhat sentimental, it contains much worth while information not readily accessible otherwise.

A few slips creep into the technical descriptions attempted by the author, such as the interesting statement that the Eagle boats were driven by "oil-burning steam turbines"—but for the layman, especially of the younger generation, for which the book seems to be especially written, the inaccuracies are relatively few and harmless.

S. W. Dudley.

* * *

The Airplane and Its Engine. By Charles Hugh Chatfield and Charles Fayette Taylor. McGraw-Hill. 330 Pages. 1928.

For those who wish to learn the essential principles of flight and the present status of the airplane and its engine, this is the book. The authors are associate professors in Aeronautical Engineering at the Massachusetts Institute of Technology. Mr. Taylor is a graduate of the Sheffield Scientific School. Both of the authors have had considerable experience in actual design and development work with manufacturers and the government.

They set out to write a book for "persons interested in acquiring a sound knowledge of the basic facts and theories of the airplane—who still do not desire to give to the subject the intensive study which is essential for the designing engineer or the expert mechanic." They have succeeded in covering a wide field rather thoroughly and yet have kept the book small in size and interesting in style. The reader feels at once that the authors know what they are writing about.

The various elements of the plane and engine are first discussed and the variations and functions of each element considered. Later the combinations of these elements into the various types of modern planes are treated. There are, besides chapters on Stability and Control, Airplane Performance, Airplane Maneuvers, and Aircraft Instruments and Accessories. The volume has over two hundred illustrations, every one of which is well done and carefully chosen.

Even those who are not particularly interested in aviation (if there be such) will find this book readable. For more ambitious beginners who plan to go farther into the theory of aerodynamics and airplane design this book furnishes an excellent point from which to take off. It can be recommended without hesitation.

Philip G. Laurson,
Associate Professor of Engineering Mechanics.

* * *

The Falls of Niagara. By Glenn C. Forrester. New York, D. Van Nostrand Company, 1928.

In this small volume of about 160 pages the author presents a very readable account of the life history of Niagara.

Geological controversies are avoided and the reader allowed to give undivided attention to the succession of geologic events which have left their records over the entire Great Lakes area extending as far westward as the outlets into the Mississippi and as far eastward as the Saint Lawrence and the Hudson. Ontario Dome, erosion, escarpments, advance and retreat of glacial ice masses, elevations and subsidences, prehistoric lakes, rivers and gorges are all fitted into a scientific narrative of compelling interest. Numerous maps, sketches and photographs effectively supplement the text.

Works of man which affect the scenic beauty of the Falls are discussed briefly and the author disposes of the prevalent idea that the Falls are cutting back so rapidly as to be self destructive within a few decades.

In a brief concluding chapter the author maps out an itinerary to the scenic and geologic features of the Falls and Gorge.

Perusal of the book should add materially to the understanding and consequent enjoyment of both the actual and the prospective visitor to this most popular of America's scenic wonders.

Charles S. Farnham.

* * *

Principles of Electric Power Transmission. By H. Waddicor. John Wiley and Sons, New York, 1928.

This technical college text conforms to the familiar orderliness of arrangement and presentation of the British author. It avoids the weakness of many English works, namely, the minimization of reference to United States practice. The author on the contrary, treats the mathematical design and analysis of transmission lines with full recognition of our usages and procedure and justifies his treatment by the following statement:—"Undoubtedly the most striking examples of power transmission are to be found in the United States. The vast country, with its enormous industrial demands situated at long distances from equally large waterpowers, can be considered as the home of power transmission schemes. Line pressures up to 220 kv. are in actual use, and a large portion of the country is one immense network of high-voltage overhead lines."

Notable features are the inclusion of more than the usual amount of subject matter on line insulation, underground cables, economics of line design, surges and schemes of protecting against them as well as protection against excessive currents.

A. E. Knowlton.

Mathematics

Nearly every member of the Department of Mathematics attended the annual meeting of the American Mathematical Society held in New York City, December 26-31, 1928. In the Analysis Section a paper was read by Dr. T. H. Rawles, while in the Algebra and Analysis Situs Section papers were read by Professor O. Ore and Mr. T. H. Enjstrom. At the General Session Professor Pierpont gave an address on "The Motion of a Rigid Body in a Space of Constant Curvature" and at the joint session with the Economics and Social Science Division of the American Association for the Advancement of Science, Dr. P. R. Rider gave two papers on statistics.

Geology

Professor W. E. Ford has been working on the revision of Dana's System of Minerology.

Professor Adolph Knopf is at present engaged in a study of the age of the Earth for the Division of Physical Science of the Natural Research Council.

Mrs. Adolph Knopf is at present engaged in the application of petrographic methods to the interpretation of the Metamorphic history of rocks.

Professor Ellsworth Huntington is away at present on leave of absence.

Professor Richard F. Flint continued his work upon the history of glaciation in Connecticut this past summer and presented the results in a paper before the Geological Society of America during the Christmas recess.

Dr. R. W. Brown will resign from the Department of Geology to join the U. S. Geological Survey at Washington.

Professor Chester R. Longwell spent part of last summer in field work in Nevada and has been working up his results since that time. He also presented a paper on the "Character and History of Continental Nuclei" before the Christmas meeting of the Geological Society of America.

A. C. Waters, Instructor in Geology, spent the last field season in Washington and Idaho, as a result of which he presented a paper on the Geology of Steens Mt., before the Geological Society of America this Christmas period.

Professor Alan Bateman presented a paper before the Society of Economic Geologists at the Christmas meeting on "Covellite-Chalcorite Relationships".

Messrs. Longwell, Agar, Bateman, Dunbar, Flint, and Knopf have just completed a thorough revision of Pirsson's Text Book of Geology, Part I, which will be published in the spring by Wiley and Co.

Mining and Metallurgy

Mr. Ulick R. Evans, who will deliver the annual Institute of Metals lecture in New York City, in February, will give a series of three lectures in the Hammond Metallurgical Laboratory on February 25th, 26th, and 27th. Mr. Evans' subjects will be as follows:

I. The Study of Thin Oxide Films—Passivity.
II. The Rusting of Iron.
III. The General Principles of Corrosion and Protection.

Physics

Dr. L. Merle Kirkpatrick, Sterling Fellow in Physics, died of pneumonia while on his vacation in Illinois, during the Christmas holidays.

Professor John Zeleny gave a paper before the American Physical Society of New York, on December 30th. Professor Zeleny's talk was on the distribution of mobilities of ions in moist air.

Dr. Joseph E. Henderson also gave a paper at this meeting. The title of his subject was "*Reflection of Soft X-Rays.*"

Mr. L. Stedman is making accurate determinations of wave lengths of shortest gamma rays from radium. A preliminary report on the work was given before the American Physical Society in Minneapolis during Thanksgiving meeting.

Dr. D. Olshevsky, Sterling Fellow in Physics, has developed a new method of getting fairly uniform high potentials for use with X-ray tubes by the employment of three transformers and three kenetrons in a three phase system.

Through the work of Mr. Malcolm Henderson and Mr. L. Stedman anyone walking about in the lower floors of Sloane Laboratory may *hear* the movement of gamma rays. The gamma rays have been slowed down to such an extent that they may be amplified and heard through a loudspeaker.

Civil Engineering

Summer courses in Plane, Topographic, and Railroad Surveying were conducted, as during the past three years, at the Engineering Camp at East Lyme. Each of the courses requires about four weeks. In addition to work in Surveying, a special course in Engineering Drawing was given for the benefit of fourteen men who were unable to take the regular course during the college year. Mr. Gleason conducted the course. A total of 173 men from the Classes of 1929, 1930 and 1931 were enrolled in the various courses given at the Camp. Professor C. S. Farnham was in charge of the Camp. Other members of the staff were: Professors R. H. Suttie and J. N. Eckle, Instructors R. B. Allen, W. H. Allison, G. M. Keith, F. R. Hughes and G. S. Gleason; Graduate Students W. A. Shapard, and W. T. Wentworth. Professor F. J. Lewis of Vanderbilt University and Professor L. E. Wooten of North Carolina State College assisted during a portion of the summer. In coöperation with the Highway Commission of the Town, a selected group of students completed a survey of the highway from the Camp to the village of East Lyme, a distance of over two miles. Desirable improvements in width, alignment, and grade were studied by the class in Highway Engineering and shown on the plans. The Town expects to complete a number of the proposed improvements during the coming summer. Recreational facilities were increased by the partial grading of a ball field near the barracks. The work will be completed this season.

Professor Tracy represented recently the University at the dedication of the new engineering building at Princeton.

Professor C. T. Bishop spent the summer working for Consulting Engineer E. W. Wiggin, designing the steel frame of an industrial building. Professor Eckle also worked for Mr. Wiggin between the two surveying courses.

Professor Kirby has been on Sabbatical leave for the first term. He spent six months in Europe, gathering material in connection with an historical study of certain fields of civil engineering. This work took him into Belgium, France, England, Wales and Germany. Of particular interest and value to him were his contacts with the foreign engineering societies,—the *Institution of Civil Engineers*, the *Societe des Ingenieurs Civils de France* and the *Verein deutscher Ingenieure*. Professor Kirby was recently elected a member of the Newcomen So-

ciety. This organization has its headquarters in London, and its object is to encourage the study of the history of engineering and technology.

Professor Farnham attended the annual meeting of the Highway Research Board held in Washington, D. C., in December.

Professor Suttie spent six weeks during the summer doing special work in hydrology and water-power engineering at the hydraulics laboratory of the University of Wisconsin.

The usual inspection trips of students in Structural Engineering and in Architectural Engineering were made to the structural plants of the Berlin Construction Company at Berlin, Conn., and the Porcupine Company at Bridgeport, Conn.

Forestry

Thirty-nine regular students are enrolled in the School of Forestry for the year 1928-29, twenty-five of them in the Senior Class. In addition, nine men are working for the Ph.D. degree under the direction of the faculty of the School. Three of them are enrolled in the Department of Forestry in the Graduate School, the remainder being in the Department of Botany.

A gift of $20,000 as a fund for fellowships or scholarships has been made to the school by Mrs. William H. Sage, of Albany, New York. The fund has been given as a memorial to William Henry Sage, a graduate of Yale College in the Class of 1865. Before his death Mr. Sage provided a fund of $300,000 for the erection of a building for the School of Forestry, in memory of his son, DeWitt Linn Sage, Yale 1897.

The executive council of the Forest School Alumni Association met at the school, November 23 and 24, 1928. A. B. Hastings, C. E. Behre, H. I. Baldwin and P. D. Kelleter were present. J. A. Ferguson was kept away by illness.

Activities and plans for the school were discussed with Dean Graves and other members of the faculty. Plans were made for the annual meeting on February 22 and for the big thirty-year reunion next year.

Professor Toumey conducted a symposium on "Climatic Factors as Affecting Vegetation" at the meeting of the Ecological Society of America, held in New York in conjunction with the annual meeting of the American Association for the Advancement of Science.

Medicine

During the past year seven professorial appointments were made in the Yale University School of Medicine. Three of the appointees came to Yale from other universities and the remaining four were promoted; two from Assistant to Associate Professorships and two from the rank of Instructor to that of Assistant Professor.

The latter group includes Dr. Theodore Sidney Moïse, now Associate Professor of Surgery; and Dr. Leon Stanfield Stone, now Associate Professor of Anatomy. Dr. John Hammond is now Assistant Professor of Pediatrics and Dr. Allan King Poole has been made Assistant Professor of Medicine.

Those brought to the Medical School from other places include Dr. Felix d'Herelle, Dr. John R. Paul, and Dr. Daniel C. Darrow.

Under the direction of the Graduate Faculty of Yale University there are at present ten Fellows conducting investigations upon certain phases of medical and biological science.

At the Osborn Zoological Laboratory, Chia Chi Wang, a graduate of Nanking University and the recipient of the Ph.D. degree from the University of Pennsylvania, is working with Professor Lorande L. Woodruff. The subject of his studies is the conjugation of *Paramecium calkinsi* Woodruff.

At the same laboratory, Ivan Nikolaevitsh Filipjev is a Fellow on the Seessel Foundation. Mr. Filipjev is a graduate of the University of Leningrad and a resident of that city. He is working on the systematics of Nematoda, using as material specimens collected by him in the North Sea.

Ethel Maud Poulton of West Bromwell, England, is also a Fellow on the Seessel Foundation. Miss Poulton holds the degree of D. es Sc. from the University of Geneva and is at present making a study of fresh water algae at the Osborn Botanical Laboratory.

Further investigation into the nature of the tubercle bacillus is in progress at the Sterling Chemistry Laboratory. Alice Gertrude Renfew and Elizabeth Gilman Roberts, both of whom have received the Ph.D. degree from Yale University, are pursuing this study under a grant from the National Tuberculosis Association.

The Alexander Brown Coxe Memorial Fellowship, new on the list of Yale research fellowships, is held by Ezra Abraham Sharp, M.D. Johns Hopkins University. Under the direction of Professor Francis G. Blake of the Department of Internal Medicine Dr. Sharp is studying the rôle of allergy in pneumococcus pneumonia.

In the Department of Physiological Chemistry three Fellows are studying with Professor Lafayette B. Mendel. Mary Elizabeth Reid, Ph.D. University of Wisconsin, is continuing her studies on the nitrogenous metabolism of seedlings. Agustin Domingo Marenzi, Doctor of Biochemistry and Pharmacy of the University of Buenos Aires, and Assistant in Biochemistry at that University, is working under a grant awarded by the Rockefeller Foundation. A Foundation has been newly inaugurated for the purpose of studying the effects of mineral oil on nutrition and upon this subject Richard Willet Jackson, Ph.D. University of Illinois, is doing research in the Department of Physiological Chemistry.

During his leave of absence from Cornell University where he is Professor of Plant Pathology, Walter H. Burkholder, Ph.D., is Fellow by courtesy at the Laboratory of Bacteriology. The subject of Dr. Burkholder's investigations is a study of those bacteria pathogenic for leguminous plants.

E. B. G.

Electrical Engineering

The Department of Electrical Engineering has been assigned additional space in the building formerly used by the Department of Physiological Chemistry, which is adjacent to the Dunham Laboratory. The north wing of this building has contained the high voltage testing equipment of the Department for several years as there was no appropriate space in the Dunham Laboratory. The increased demand for space by the electrical department has led to additional rooms of the adjoining building being fitted up for three additional purposes, research, computation and a photometric laboratory. The need for using exclusively for laboratory purposes rooms that were previously used for class room purposes and the need for adequate provision for precision instrument and calibration work, is the reason for the call for additional space.

Major D. W. Blakeslee, Corps of Engineer's Reserve, has been promoted from the Electrical and Searchlight Unit of the Engineering and Development Branch to Chief of the Administration Branch, Supply Section, Office Chief of Engineers, Washington, D. C. Major Blakeslee has specialized for many years in iron and steel works electrical engineering in all its branches.

(Continued on page 35)

Yale Engineering Association News

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

This department is prepared by the Yale Engineering Association. The Editors of the YALE SCIENTIFIC MAGAZINE are not responsible for its contents.

A NEW aspect of the housing problems of Sheff. is brought up by Mr. Harkness' recent generous gift to Harvard for the development of the "group plan" of dormitory. Is not the present club system in Sheff. a good start toward just what Mr. Harkness suggests? Should we not look into its possibilities before we assume that completion of the Sheff. Quadrangle would be the only solution of our problem? The present condition where the comforts of fraternity house life are limited to a select few must be remedied. But why couldn't more houses be built by the University to supplant the unsightly and unlivable houses on Grove Street and Temple Street?

We are not familiar with all the arguments in favor of Mr. Harkness' proposal for Harvard, but the fact that Sheff. already possesses a number of "group units" in existing club houses should lead the University Authorities to consider the plan seriously in Sheff.'s behalf. We agree with the University that the housing situation in the college is already too near solution to permit serious consideration of Mr. Harkness' proposal.

One of the obstacles in the way of all dormitory proposals for Sheff. has been the existing houses with the heavy investments of the clubs in them. Any successful plan must take them into consideration.

* * *

THE report of the Department of Personnel Study and that of the Placement Bureau, which appear in this issue, should be read by every alumnus. The significance of developments in these bureaus should be thoroughly appreciated.

Yale has responsibilities to its sons which involve certain functions which until recently have been performed in a very haphazard way or not at all. When only a limited number of ambitious boys attempted a college education and most of these had considerable cultural background, the old idea of taking in everybody who could pass entrance examinations, and leaving each student to his own devices in working out his college courses and activities, may have been justifiable, but now that 200,000 boys are entering college each year and a large proportion of these boys have no definite purpose in life and little ambition beyond the supposed advantage of being a "college man," a national university such as Yale must do everything possible to secure only students who have the personalities and intellectual qualities which promise well, and must be in position to counsel its sons wisely while in college and also during the first years after graduation.

This does not mean definite guidance or control except in upholding scholastic standards. It does mean, however, that the University shall have at its disposal the facts of life that the student should know and shall be prepared to place these facts before the student in the right light and in a way that shall arouse his interest.

As stated in the initial report of the Director of the Department of Personnel Study:

"It is perhaps advisable to emphasize in respect both to occupational and educational advice that this Department has no intention of making a student's decision for him. The responsibility for the choice either of a course of study or of a career remains with the individual, and we therefore do not plan to determine such choices for the student. As we see our function in these respects, it is rather to serve as a bureau of information which will enable the individual to reach his own decision on the basis of more complete and reliable data, conveniently accessible. The accumulation of such data will of course be a long process, but requests from students as well as members of the Faculty indicate that there is a very real demand for such service."

The progress in this Department in the brief period since its inauguration has been quite remarkable and it is progressing steadily on a program which promises much which our Association has earnestly recommended. Already it is in position to give sound advice to seniors in their choice of careers and to all undergraduates in matters of orientation. At least, a good start has been made in preparation to perform these functions.

That such assistance is needed is evidenced in the very practical matter of securing jobs for seniors. Last year nearly half of the graduating class consulted the Department and 38 per cent registered for placement. 122 men were placed directly by the office.

Other work of the Department is discussed in the report.

The Placement Bureau at the Yale Club in New York very properly is closely associated with the Department of Personnel Study and the Bureau of Appointments. Its function not merely is to find jobs for applicants. Its purpose is to have eventually definite knowledge of the progress of every alumnus during the first few years after college and to counsel with these young men regarding progress in their present jobs as well as to find new jobs for them when they have to move. In this way the Bureau not only will help the individuals applying to it, but will be put in position to furnish to the University the results of experience which will be of increasing value to undergraduates and to the faculties.

Now, where does the Yale Engineering Association come into this picture?

In very definite and practical ways. In the first place, every member should understand clearly what is going on and what these recent developments mean to his boys, to his friends' boys and to employers of young men. They mean that Yale not only has the facilities for educating these boys; it has a genuine interest in them personally and in their careers.

In the second place, these developments mean that boys will be oriented better and better while in college. It will certainly follow that a greater proportion of those who enter the Scientific School will be boys capable of making good use of its facilities

and will come out prepared to do well the things which we expect of Sheff. men.

Finally our young graduates can depend upon the Placement Bureau to give them wise counsel and assistance and in turn they have a definite responsibility to their Alma Mater to keep the Placement Bureau advised as to their progress in order that the boys who follow them may profit thereby.

DEPARTMENT OF PERSONNEL STUDY

[*Extracts from Annual Report of Director.*]

As emphasized previously, effective development of Senior placement work hitherto has been seriously handicapped by lack of reliable and adequate factual information concerning the professional and business callings which our students typically enter. During the past year, therfore, a beginning has been made toward meeting this need. A pamphlet entitled "The Choice of an Occupation," published in January, discusses certain principles which seem basic for the young graduate's successful adjustment to his business or professional career. An attempt has also been made therein to classify various typical occupations functionally, and specific figures have been cited showing normal expectancy of monetary return for college graduates in different occupations.

As an adjunct to this general introductory pamphlet, short descriptions of some twenty specific occupations have also been prepared. These discuss methods of training, nature of the work involved, opportunities offered, etc. The Engineering Departments of the Sheffield Scientific School, which during the year published extremely valuable pamphlets descriptive of their respective professions and of the courses of study leading thereto, have been particularly helpful in this connection. Other members of the Yale Faculty, as well as professional and business authorities elsewhere, have also given valuable assistance in the attempted analyses of occupations. It is hoped to publish by January, 1929, another pamphlet combining the general prefatory material contained in the earlier one with more specific data relative to particular careers. The demand for such information is well illustrated by the number of inquiries already received, both from students and from educational and business organizations, for even the very incomplete material published this year.

SENIOR PLACEMENT

As had been anticipated, more Seniors than previously had registered with the Bureau of Appointments consulted the Department this year concerning their future plans. A large part of this increase was due to the extension of this Department's service to include not only information about industrial positions but conferences on professional study as well. There was also an increase in the number of business registrants. The net total number of Seniors consulting the Department was 331 or nearly half of the combined Senior classes in the two Undergraduate Schools. In addition, a number of students in other classes also requested occupational data of one sort or another.

Even with the additional space available this year, the number of industrial representatives coming here to interview Seniors occasionally proved more than both the Personnel Department and the Bureau of Appointments buildings could properly accommodate. In general, however, there was less call for college men this year than for several seasons past. Business conditions apparently were responsible for the decreased number of openings. Despite this falling off in positions, the number of Seniors placed directly in business positions (exclusive of those indirectly assisted and of the professional group) slightly exceeded last year's total. This represented, however, a somewhat smaller ratio of placements to registrants. The quality of opportunities offered was relatively high, firms wanting either one or two of the best men or none at all, and usually having excellent openings for those who measured up to the highest standards of selection.

The complexity of present-day problems seems to justify the emphasis we have attempted to place upon the importance of professional training, whether for business or for other callings. It was, therefore, gratifying to note, from polls of Seniors' occupational plans made in the fall and spring, that interest in professional studies, which has tended in recent years to decline, is now apparently once more on the increase.

Information obtained from the Senior polls, for a total of 664 men (90 per cent of the two Senior classes in both Yale College and the Sheffield Scientific School), showed 375 (56 per cent) planning to enter business directly or to pursue graduate study in business administration, and 241 (37 per cent) planning to enter the professions (architecture, law, medicine, teaching). Of the latter, 57 (9 per cent of the total) are expecting to make teaching their profession—some after graduate study, and others, particularly in the secondary school field, at once. This marks an encouraging gain in the number of prospective teachers over corresponding figures for the last few years.

Only 7 per cent of the Seniors reported at the end of the year that they were still *wholly* undecided as to their future plans. Of these, about half were expecting to travel before reaching an occupational decision. Twenty per cent of those planning to enter business, however, had not, up to the time of graduation, completed definite arrangements regarding their work. Thus, over a quarter of the Senior class finished their four years in relative or entire indecision regarding the future. Corresponding data from the fall poll showed 23 per cent wholly undecided, 35 per cent expecting to enter some business but without having reached any specific conclusions in that respect, and only 42 per cent whose choice of a business or professional career was, at that time, definite.

If this year's figures can be taken as characteristic of our student's occupational plans, it would appear that more than half of the class, in the fall of Senior year, are undecided about their future careers; and that about one quarter, up to the time of graduation, have still failed to reach a complete decision.

ANALYSIS OF OCCUPATIONAL PLANS OF YALE COLLEGE AND SHEFFIELD SCIENTIFIC SCHOOL SENIORS

Total number in Class:	
College Seniors	516
Sheffield Scientific School Seniors	223
	739

Distribution.

	College	*Per cent*	S.S.S.	*Per cent*	*Total*	*Per cent*
Business and business study	220	48	155	77	375	56
Professional study	177	38	41	20	218	33
Teaching	27	06	..	..	27	04
Travel and undecided	38	08	6	03	44	07
	462		202		664	

Total number replying—664 (90 per cent of Class).

RECORDS

A central cumulative undergraduate record system has been initiated. Cards prepared last fall for the Freshman Class (1931) are designed to bring together conveniently much of the data about students which different departments of the University have been collecting in the past, but which have heretofore been scattered among different offices and therefore were not available in any one place. Starting with school and entrance information, the student's photograph, and his University registration blank as a basis, other objective data will be added at regular intervals regarding each individual's class-room and extra-curriculum record, self-support employment or scholarship aid, if any, etc.

Such a cumulative data file forms an indispensable basis for general personnel work. As the information chiefly desired is objective in nature and may be secured by combining items from the partial records already maintained by different offices for their particular purposes, its centralization involves neither inconvenience to the student nor inclusion of any strictly confidential material. Each year a set of cards will be prepared for the incoming class, until eventually a simple but comprehensive file will contain the essential records of all undergraduates.

CURRICULAR ORIENTATION

A series of conferences held early in the year with Freshman Counselors suggested the need also of a central bureau of information about courses of study and other orientation data. It has not been possible thus far to meet adequately the demands of students and their Counselors in this respect. A plan has been formulated, however, which should lead gradually to the collection of such information. The Personnel Office feels that it can serve both Faculty and undergraduates by establishing, with the coöperation of the various Departments of Study, a central clearing house for data concerning the course of study.

PERSONNEL RESEARCH

Though a certain amount of investigation into personnel questions had been contemplated, more demands of this nature were made upon the Department in its first year than had been expected. The problems studied included:

Analysis of the Sheffield Scientific School enrollment question.

Validation of Law School examination questions.

Evaluation of various criteria of selection used in selective admission to the Law School.

Validation of a scale of professional interests among physicians.

Study of the relation of curricular success to participation in extra-curriculum activities.

Analysis of subsequent academic mortality among students who had completed their Freshman year with various degrees of scholastic deficiency.

Comparison of performance in the Comprehensive English Entrance Examination, with that in Freshman Year English.

Investigation of the possibility of combining pre-matriculation academic criteria (school record, entrance examination average, and scholastic aptitude test score(into a single index predictive of individual grades in the Freshman Year.

This last study has proved particularly interesting and gives promise of results applicable both to the problem of selective admission and to that of Freshman orientation. Until it has been rigorously tested for several years, no assurance as to the permanent value of this procedure can be given, but the preliminary investigation made this year certainly seems to justify further analysis. Consequently the Department has been asked this summer to compute the predicted Freshman Year grades of all candidates for admission to the next Freshman Class (1932).

The first term averages for members of the Class of 1931 were accurately predicted last fall by this method in 75 per cent of the cases. The correlation between predicted and actual first term grades (.71 for the Class as a whole) was nearly as high as that between first term and second term averages (approximately .78). If this degree of reliability in prediction can be maintained, there is no question as to the usefulness, in many ways, of the results. The method used is a modification of that initially developed at Princeton University by Professor C. C. Brigham, to whom the Department is much indebted for his assistance in this connection.

* * *

THE following communication has been received from Mr. Samuel S. Board, '11, Director of the Yale Placement Bureau:

"When a freshman makes the momentous decision and arranges to take the academic course he may have a vague hope that his studies will help him later with his work but when he elects a scientific course it is in most cases with the expectation that he will shortly after graduation be able to use his training as well as his education in some lucrative way.

"He ought to be able to do so of course, but frequently circumstances tend to force him into totally unrelated lines of activity or he finds himself tied to a job which makes it almost impossible for him to keep in contact with chances for growth and advancement. Under such conditions his first impulse is to quit forthwith and frequently this results in periods of unemployment which help to negative any personal and financial advances he has made.

"It was because two Sheff. graduates of the class of '96 S. realized some of these limiting conditions and persisted in the attempt to bring together various efforts at placement which were being made for Yale men that the Yale Graduate Placement Bureau, Inc. was formed three years ago. This was supposed to be and is, much more than an employment agency. It takes hold where the now efficiently organized Department of Personnel Study leaves off at graduation and attempts to do three things for Yale men: First, give them the facts about work opportunities and working conditions. Second, help them to check their experiences against those of other men and to lay out an intelligent plan. Third, if then necessary, to get them suitable jobs.

"The forms which this sort of service can take are legion but one or two instances may help to illustrate it. Last summer a mechanical engineer came into the office, who had spent three years working for a large public utility only to find that his abilities weren't sufficiently suited to the work to allow him to progress satisfactorily and he had quit in despair. He was shown the general range of work that he could do profitably, helped to size up his own abilities and told where he could get more specific information about the lines which interested him. As a result he dug up another job himself which gave every promise of being worthwhile.

"Another man came in who had just returned from his sexennial where the general talk of the big money various of his classmates were making had thoroughly disgusted him with his own job. Only a few minutes' talk satisfied him that he was making at least as much as the average graduate of his age and that, in addition, his company was giving him an unusual chance to so learn the business that he could shortly take over greatly increased responsibilities with the opportunity then of earning a much larger salary.

"Scores of other men have, of course, come in and merely needed a new job because the one they were on was finished, unexpected business conditions had thrown them out suddenly or they needed to earn more money than they had so far been able to. These are sent out as promptly as possible to look up positions which may be listed with the bureau, are furnished the weekly bulletin of positions open and on occasion arrange for letter campaigns to be conducted for them. In the past three years more than 440 positions have been secured for the 2500 men who have applied in addition to the information and counseling service provided free of charge. The only fee is a moderate one where actual placements are made.

"Thus the Bureau is endeavoring to help the University follow through the education and training which is provided in undergraduate days so that the world as well as its graduates may profit more fully therefrom. Under the leadership of Mr. George T. Adee, '05, who has recently become President, we hope to bring it to a new level of effectiveness and usefulness.

"SAMUEL S. BOARD, '11,
"Director Yale Placement Bureau."

THE annual dinner of the Yale Engineering Association, at which the members of the graduating class in Sheff. are guests of honor, will be held at the Yale Club in New York on March 27 at 8 o'clock. While the program has not yet been announced by President Smith Ferguson it is expected to be of current interest.

MEETING WITH THE PROFESSORS OF THE ENGINEERING DIVISION

This Association is kept in touch with the plans and activities of the Scientific School through contacts of its committees with the men of the faculty. The last meeting of this character was held in the Board Room of South Sheffield Hall on Monday evening, January 21st. This time a special committee of seven members of the Yale Engineering Association met with the Executive Committee and the Committee on Outside Contacts and Bulletins of the Engineering Division of the School. The meeting was arranged for the purpose of co-operating with the faculty in the development of new plans which the Division has under way.

Professors Dodge, Dudley, Crane, Curtis, Hall, Hastings, Kirby, Matheson, Milligan, Seward, Scott, Tracy and Wohlenberg with Dean Warren and Registrar Havemeyer represented the Scientific School and Messrs. Starr Barnum, Clarence Blakeslee, Henry Brewer, Horace Cheney, Smith Ferguson and Oliver Lyford represented the Yale Engineering Association. The party met at the Graduates' Club as the guests of Clarence Blakeslee for a get-together dinner before the meeting.

Following the recent organization of the Engineering Division, committee appointments had been announced at a meeting held in the afternoon of the same day. The forming of various committees, such as the one on Outside Contacts, impressed our members as an excellent move and one which sets up the machinery not only to study the several vital problems now facing the school, but to actively prosecute whatever line of action may seem desirable.

The principal subjects discussed at our meeting related to ways in which the faculty and the association could co-operate in securing a full recognition of the eminence of the school and its courses of study, and in obtaining the highest grade of students. The discussion was characterized by clear, cool-headed, co-operative thinking, chiefly centered upon the following points:—

The demand for college graduates capable of correct, analytical reasoning is greater than ever before. Such men are particularly necessary in the administrative and research departments of the manufacturing and mercantile industries, but are wanted in many other fields.

There is a greatly increased call for men in the interesting work of the great Industrial Research Laboratories.

Sheff. is as well equipped with plant and personnel as any other institution to prepare young men for either of these branches of business and engineering. That many employers know this to be true is evidenced by the fact that nearly two hundred firms applied last year for high grade seniors.

Yale Alumni must be convinced of these things and means found to acquaint boys and their fathers and future employers with the up-to-date courses at Sheff., the character and practical experience of the men who teach these courses and the fact that there is a constant demand made upon Sheff. for more young men than are now available. In this connection it was pointed out that both the faculty and the Department of Personnel Study seek to place boys only where good training and a fair chance of advancement is assured.

Dean Warren told of the necessity of more scholarships and fellowships in Engineering and suggested that the Yale Engineering Association provide one or more of such scholarships. The idea impressed the representatives of the Association very favorably.

The Dean also advanced the thought that one or more representative alumni in each of a number of cities could be of great assistance in advising prospective students regarding entrance conditions and the procedure in selecting courses. To give such advice requires good judgment as well as a rather thorough knowledge of conditions at Yale and the requirements of the various courses. If members of the Association are in a position to render a service of this nature the school will provide adequate information.

Profesor Hastings, who is Chairman of the Engineering Divison, believes that the Yale Engineering Association should be able to open opportunities for our graduates in organizations which have not previously employed our men. High grade graduates might well form business connections which would greatly extend the reputation and prestige of the school in such institutions.

The meeting lasted until 10 o'clock in the evening. All of these matters were given a thorough preliminary discussion and there is a general conviction that much constructive work can be done along these lines which will be of help to the school in turning out a larger number of high grade men. The plans discussed at this meeting will be placed before the Executive Committee.

PERSONALITIES

(Continued from page 27)

sor Havemeyer is a member of numerous scientific societies and is the author of several books dealing with ethnography and anthropology. In spite of his many official responsibilities and his professional work, he has found frequent opportunity for travel and has played a prominent part in the social life of the University and community.

Whether or not Sheff men think of Loomis Havemeyer as an administrator, a teacher or an author, they will always remember him as a perfect gentleman, a very human companion, and a sympathetic and understanding friend.

ELECTRICAL ENGINEERING

(Continued from page 31)

In addition to the regular courses of the New Haven College (conducted as a night school by the Y. M. C. A.) certain of which are held in the Dunham Laboratory, special work has been inaugurated in connection with the New Haven Foremen's Association. A course of ten lectures is being given on industrial applications of electricity for factory illumination, electric welding, electric heat, industrial motors and motor control. These lectures are being given by Professors Scott, Hall, Knowlton and Mr. Abbott. The course was organized and is under the direction of Professor Knowlton.

ELECTRIC WELDING ON THE STERLING LIBRARY.

(Continued from page 21)

strength required for vertical load of books and persons is scarcely more than nominal—books, even the heaviest of mathematical or philosophical treatises, averaging scarcely more than 25 pounds per cubic foot, and 100 lbs. live loading per square foot of platform being ample to cover even a simultaneous rush for information.

The nature of the building makes large clear spaces unnecessary. Supporting columns can therefore be placed very closely, and this with the light loading, has developed a very specialized form of construction which at once attracts the attention of the beholder.

Both vertical and horizontal members are completely special. The former are built up, consisting of an I beam whose flanges are narrow bulbs, and to whose web, on either side, are riveted angles, the whole member thus having a cruciform section whose axes are approximately 4" and 5". Riveting is used in the fabrication of these members rather than welding, since this work is not done in the field but in a factory well equipped for quantity production. Also this operation is especially advantageous to riveting in that a single rivet goes through both angles and central beam. There are, roughly speaking, 15 miles of these columns.

The horizontal members are very light pressed channels, 5½" deep, also manufactured by the contractor, Snead & Company, who, being specialists in bookstacks, have found it practicable to install a great deal of machinery for the production of these unusual shapes.

Such bookstacks, in the ordinary smaller sizes, have been bolted together. In the Yale stacks, however, in view of their extraordinary height and magnitude, bolts were regarded as unsuitable and the choice lay between riveting and welding. When silence, greater rigidity, and somewhat lower costs led to a decision for the latter, Snead & Company retained Gilbert D. Fish, Consulting Engineer for the Westinghouse Electric & Manufacturing Company, as consultant and advisor.

Mr. Angus McDonald, President of Snead & Company, is so well pleased with the results of welding in this instance, that all stacks of notable size erected by his company will probably hereafter be welded.

In erecting this structure the various members were carefully plumbed, aligned, and then bolted together with stove bolts, all that was necessary being to keep them in position until welded. These small bolts were left in after welding, but are not thereafter relied upon for any strength.

Two 200 Ampere Welding Outfits Sufficient.

The welding equipment used consisted of two standard 200 ampere Westinghouse welding outfits, drawing 3 phase, 60 cycle alternating current from the local supply mains and converting it by a motor-generator to direct current for the welding arc. No especial supply lines to feed the machines were necessary. These portable welding equipments, recently perfected, are complete integral units, every part of which is intended solely for this duty—their compact and rational design contrasts strongly with older welding outfits whose appearance shows them at a glance to be assemblies of miscellaneous parts mounted upon a cart.

As in any form of construction, satisfactory work requires competent operators. No difficulty was experienced in this regard, as two welders of previous experience and satisfactory skill were readily obtained. No especial training was, therefore, necessary.

(Continued on page 42)

THE SCIENTIFIC METHOD RULES THE AGE

(Continued from page 19)

Many other important industries have had similar experience.

Let us examine the automobile industry closer. Between 1914 and 1925, this industry had the experience expressed in index numbers, using 1914 as a base:

	Increase
Production	998
Primary Power Used.............	485
Productivity	310
Unit Price Cost (Decrease)........	69

all of which is somewhat typical of American industry generally.

Five years ago, Elizabethton, Tennessee, had 2,400 inhabitants. Today, it has over 12,000 and promises to grow shortly to a city of 150,000 inhabitants. The reason for this is that a plant was established there to make artificial silk (not rayon) which so closely looks like, feels like and wears like silk, that it is impossible for even experts to detect the difference without a chemical analysis.

The international aspect of this development can be grasped when it is realized that last year we imported from Japan silk valued at \$334,000,000 and from China, more than \$50,000,000 worth of silk, a total of \$384,000,000. If all this trade is obtained in five or ten years by an American product, what is to become of the laborers engaged in this industry in Japan and China?

We sometimes hear coolie labor spoken of as cheap labor. A coolie works ten or twelve hours a day. If he works hard and stops for one meal, a bowl of rice, he can move one ton one mile in a day, for which he gets 20 cents. We move a ton of coal a mile for less than 1 cent. This is not only true in transportation but in every line of industry. The chief reason for this is the scientific method has been more generously applied to the problems of life in America than in Japan or China, or any other country.

America Leads the World.

This is the reason for our great progress. The facts are that an American workman produces many times more than the workman of any other country. As a consequence the annual per capita income of the American people is five times that of England; nine times that of Germany; and 22 times that of Italy.

American engineers and scientists have not only made great contributions to the earning capacity of the American people but have contributed mightily to the building of modern civilization. J. Ellis Barker, an eminent English economist, has recently pointed out that "Americans have invented the steamboat, cotton gin, sewing machine, telephone, typewriter, talking machine, incandescent light, linotype, motion picture machine, airplane, vulcanization of rubber, modern agricultural machinery, and modern boot-making. These American inventions have revolutionized transportation, industry, agriculture and commerce, and have vastly increased man's power over nature."

This short journey into the realm of knowledge and utility, discovered, explored, and charted by pure and applied science, has been sketchy and incomplete. However, it is hoped that it has been sufficiently illuminating and stimulating to enable one to properly evaluate the tremendous significance of an engineering course. An engineering career, moreover, consists not merely of using a slide rule, or a hand book, or pulling a switch. Rather it is one devoted to penetrating the realms of the unknown and the unused to the end that they may be converted into agencies for enriching the physical, mental and spiritual powers of man-

kind. And as these noble objectives are realized, civilization itself more nearly reaches the highest and noblest aspirations of mankind.

Therefore through the pursuit of the technique of analyses and syntheses, and a knowledge of the forces of nature and matter, man is equipped to make a worthy contribution to the richer and better things of life, and to improving the well-being of the masses of humanity.

THE TREND TOWARD SAFETY IN AVIATION

(Continued from page 13)

It is a Scotch trait to be careful, and because of their carefulness the Scotch have been the target for jokes ever since Caesar found that there were people living in the north of England, but in aviation it pays to be careful. First, be sure your pilot is capable, experienced, and in good condition. Secondly, be sure that the plane has been receiving reliable inspection. Lastly, be sure that the weather permits the type of flight you are going to make. If everyone would do this, we could cut our accident total down to practically nothing.

NEVADA DISCLOSES SECRETS OF PREHISTORY

(Continued from page 10)

A wide range of climatic and other conditions is indicated by these fossils and the sediments associated with them. During the geologic epoch immediately preceding historic time elephants, camels, horses, and other large animals roamed the wide valleys which now are desert wastes. The general features of the landscape were much the same then as now; but evidently a more hospitable climate permitted the growth of plants to provide food for a large animal population. In still earlier periods conditions were favorable for the growth of forest trees. Large petrified trunks are common in some of the compacted sand and mud deposits.

Man himself has left ancient records in southern Nevada, although his advent is recent in a geologic sense. Ruined houses made of sun-baked clay mark the sites of large towns (Fig. 9); and relics found in these houses indicate a civilization much above that of the modern Indians. Old picture writings, some of which exhibit considerable skill, adorn the rocks at many localities, and signs mark the positions of trails and springs. Archeologists who have studied these relics estimate that the civilization they represent existed at least 2000 years ago.

. . . an empire hung on that strap . . . .

ELECTRIC WELDING ON THE STERLING LIBRARY

(Continued from page 36)

The welding machines remained on the ground until the building had reached about half its height, when they were hoisted to a new position for the remainder of the work.

No problems whatever arose as to the operation of the welding machinery, nor as to the ability of the men to keep up; in fact, the two welders were able to gain ground on the rest of the work, and at times had to stop welding temporarily, to allow the other construction to regain its lead. The adequacy of two welders in this regard contrasts with the need for probably seven men had two pneumatic riveting hammers been operated.

It will be understood of course, that beside the bookstacks, the library includes also the reading rooms, halls, offices and other facilities common to libraries, which are of conventional construction.

The architect for the new library was James Gamble Rogers, of New York, who also designed the Harkness Memorial.

Gunvald, Aus & Co. of New York were the consulting engineers, and Marc Eidlitz and Co., of New York, the general contractors.

Snead and Company of Jersey City, specialists in bookstacks, were entrusted with this portion of the work, and fabricated all the steel members of the stacks in their plant. Leake and Nelson of Bridgeport, subcontractors under Snead & Co., executed the field erection and welding.

In the opinion of the Westinghouse Electric & Manufacturing Company, electric welding is certain to replace both riveting and the use of castings, not merely in special cases, but very generally. Evidence of this faith is found in the numerous buildings erected by the Company for its own use, in two completely electric-welded railway bridges (the first), and in the construction of large electrical machinery, in whose rotating parts welding probably finds a more severe duty than it is likely to meet in any building structure.

Bookstacks of the magnitude of Yale's new library, will, it is safe to say, always be exceptional since the number of communities which demand four million books seems permanently limited; but it may well be that its uniqueness as an example of welded construction will be very short-lived—it may in a few years be considered merely as an early example of what will by that time have become nearly universal practice.

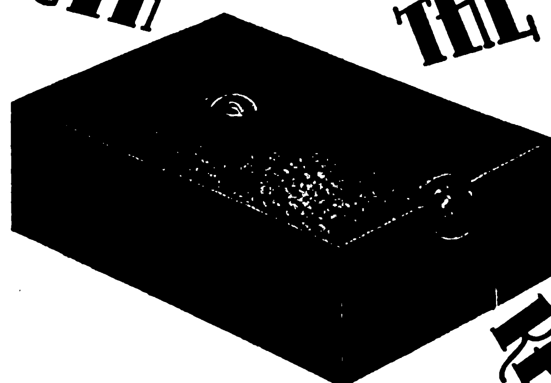
NEW INVESTIGATIONS ON TUBERCLE BACILLI

(Continued from page 20)

Much time will be required to elucidate fully the nature of the highly complex products that are present in the bacillus, but their great biological significance will justify the labor.

An investigation of such scope and magnitude as the one under discussion requires carefully coordinated cooperation between chemists, bacteriologists, biologists, immunologists, and workers in experimental medicine. Commercial bacteriological laboratories furnish raw material in the form of large quantities of tubercle bacilli. In this cooperative research, the Sterling Laboratory functions as the chemical unit in isolating and purifying the active principles of the bacillus which are then distributed to biologists and immunologists for further studies. In this work chemistry and the resources of the Sterling Chemistry Laboratory are devoted to the service of the biological and medical sciences for the ultimate benefit of all mankind.

STRENGTH THE STEEL BALL



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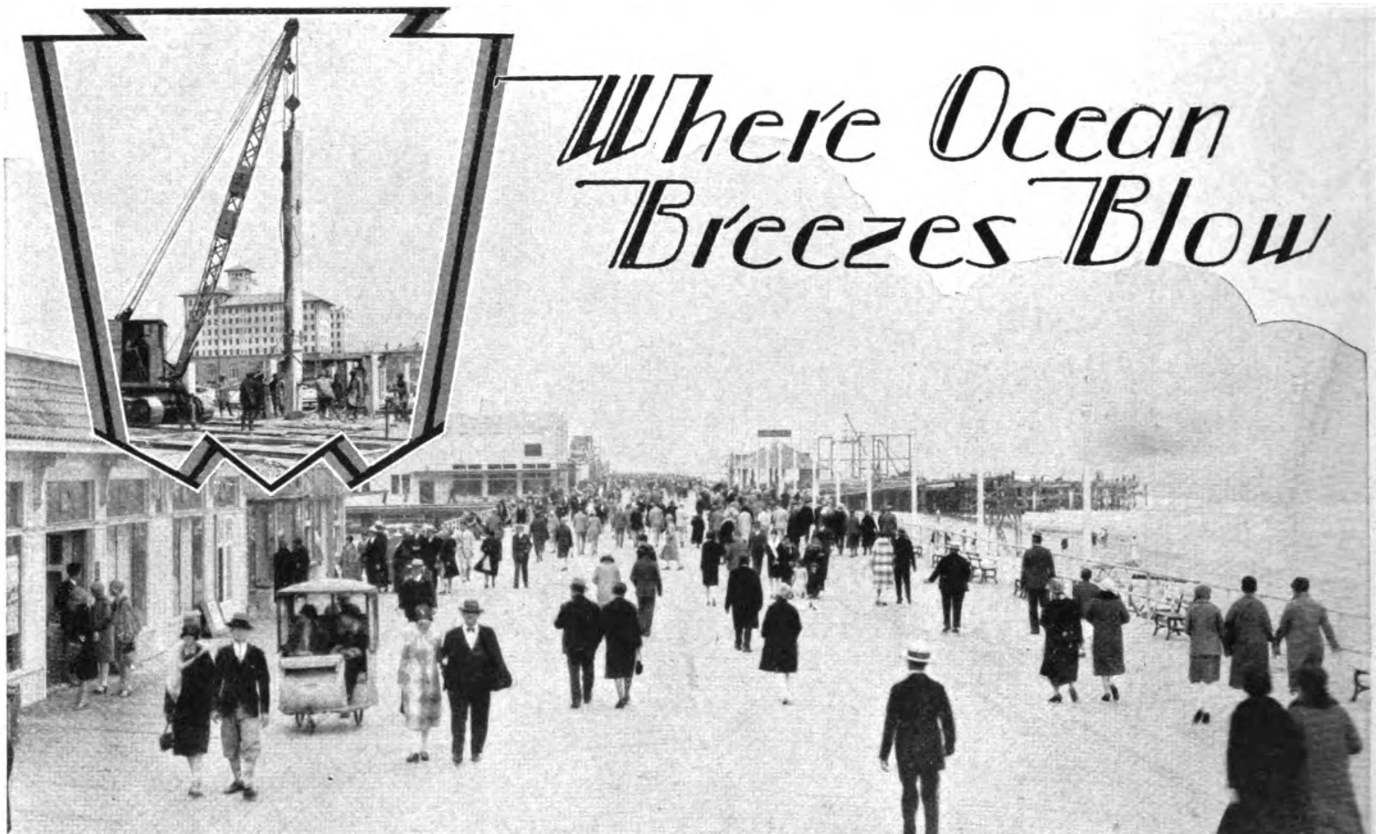

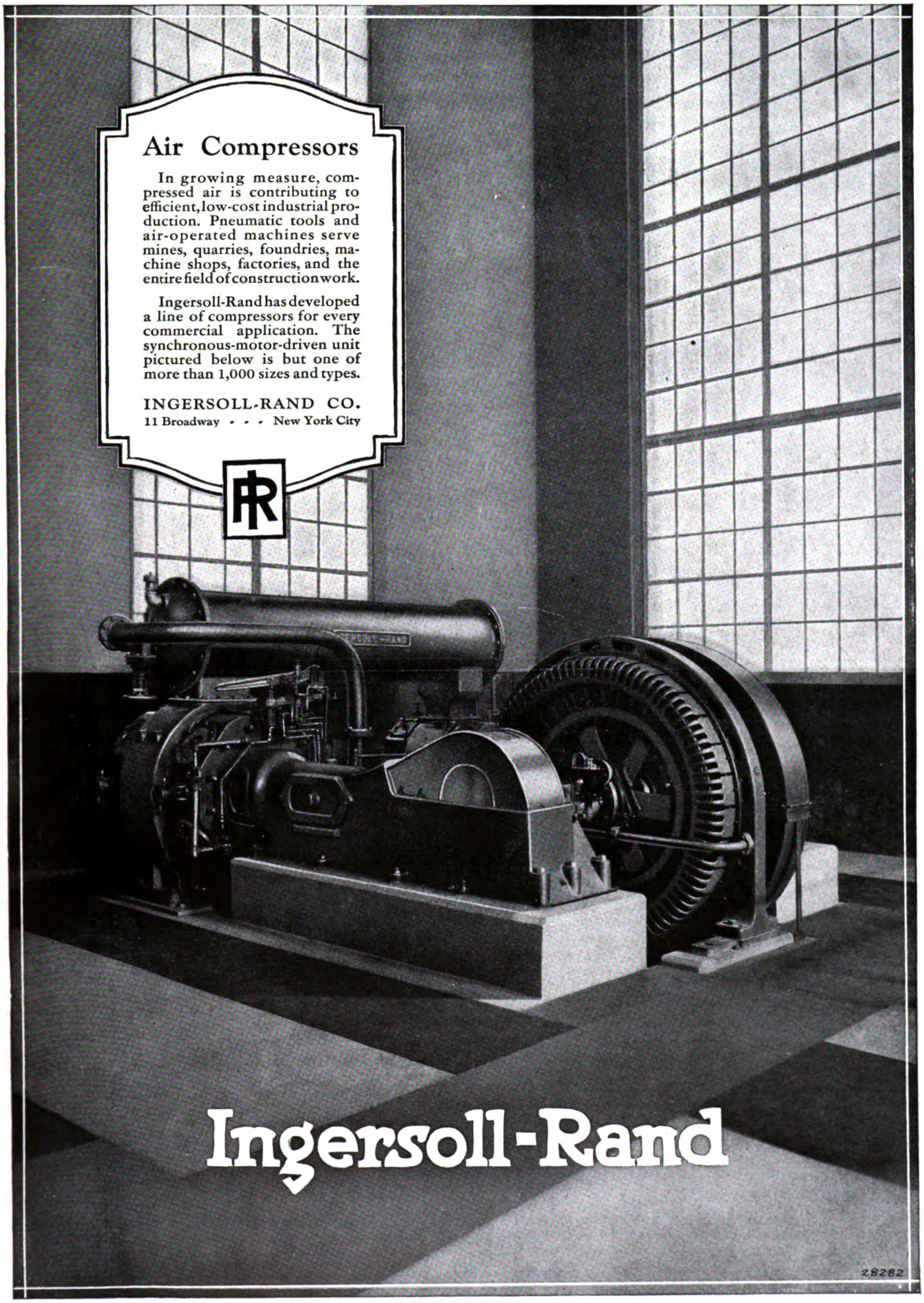
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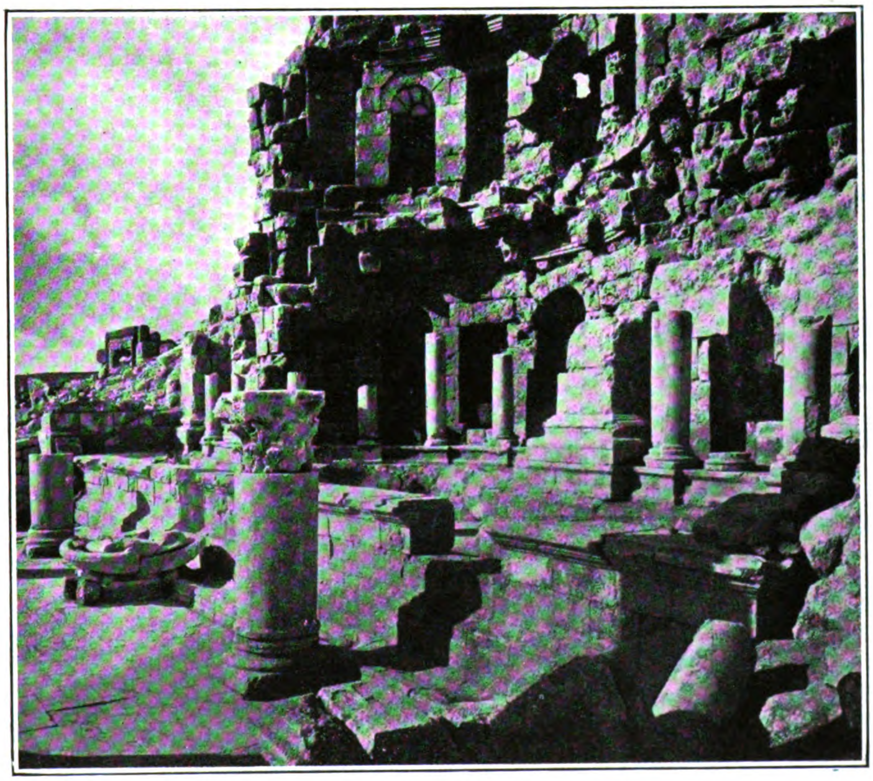
THE YALE SCIENTIFIC MAGAZINE

VOL. III MARCH, 1929 No. 3



THE NYMPHAEON AT GERASA

Public fountain of the Gaeco-Roman city, supplied from lead mains emptying through eleven apertures. Probably a shrine for Dionysiac rites. Ruin adjoining the church excavated by Yale-British Archaeological Expedition in Transjordan. (See page 13).

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N. Y. Times, Dec. 1928

NEW YORK EDISON BUYS 3 RECORD-SIZE BOILERS

Will Drive Largest Single-Unit Generating Machine in World at East 14th St. Plant.

Matthew S. Sloan, president of the New York Edison and associated companies, announced yesterday the closing of a contract with the International Combustion Engineering Company for three boilers that will be the largest ever built. Each will be about as high as an average eight-story building. They are to be installed in the East River generating station of the New York Edison Company at Fourteenth Street and will supply steam to drive the largest single-shaft, single-unit electric generating machine in the world, a 150,000 kilowatt turbo-generator now being built by the General Electric Company.

* * *

The over-all height of the new boilers, which are of the Double Ladd type with fin tube water walls, will be 95 feet, with furnaces 23 feet wide and extending back 65 feet. Each will supply a maximum of 800,000 pounds of steam an hour at a temperature of 700 degrees Fahrenheit, at 425 pounds a square inch pressure. The heighth of the boilers is approximately that of an eight-story building, allowing twelve feet for each floor.

With a heating surface of 60,000 square feet each, the compactness of the battery of boilers will make them not only the greatest producers of steam in the world but also the most economical for the space occupied and the coal consumed. Each of the boilers will require 80,000 pounds of coal an hour, or nearly 1,000 tons daily, if operated continuously at that rate.

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THE YALE SCIENTIFIC MAGAZINE

C O N T E N T S

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Geological Divining Rods and Geophysics

Modern Geological Divining Rods are the Scientific Successors of the Forked Hazel Twigs Used in Ancient Times to Locate Precious Minerals

By Professor Alan M. Bateman

As alchemy was the forerunner of chemistry, so was the witch stick or divining rod the forerunner of modern geophysical instruments. From the time of the ancients the quest for metals, precious stones, and water has acted as a strong incentive to search for treasures buried beneath the Earth's surface. Man's acquisitiveness for these substances helped to make him a believer in magical methods by which such hidden treasures might be found. The "diviner" or "witch stick man" has thrived upon the easy credulity of his followers for over 2,000 years. The same incentive has today given rise to the development of precise scientific instruments and methods whose foundation is physics and mathematics. They are used, and with success, to locate mineral substances that lie within the earth. The dreams of the early "diviners," no less than those of the alchemists, have come true; metals and petroleum are now being discovered by means of the modern geological divining rods.

The Old Divining Rod.

It is interesting, in view of the antiquity of the use of the divining rod, to find that there are many people even today who firmly believe that their forked hazel twig will bend down in their hands when they walk above buried treasure or underground water. Others are merely charlatans.

The antecedents of the divining rod are "lost in the mists of antiquity." Mr. Rickard points out that a suggestion of the forked twig, the *virgula divinatora* of the Latin writers, is to be found in the rod of Moses with which he drew water from the rock of Horeb, and in the wands of Minerva, Circe, and Mercury, whose magical power is familiar to classical students. Herodotus writes that the Scythians detected perjurers by means of rods, and Rossiter Raymond says that Ctesias speaks of a rod of wood which attracted gold, silver, and other metals, and precious stones. A true divining rod, to be sure!

Whatever its antiquity, the use of the divining rod to discover hidden treasure became general in Europe, notably in Germany, in the Middle Ages. The scientific explanation of it at this period was "affinity," a word under which was concealed a little science together with a vast amount of ignorance and superstition. There was general acceptance of the alleged operations of the divining rod as true, and many quasi-scientific theories were advanced to account for it. But it must be remembered that a belief in demonic agencies was still active at this time.

The subject of divining rods was discussed at length in 1556 by Agricola, a keen observer and wise reasoner, in his "De Re Metallica," with which we are familiar, thanks to the scholarly translation from the Latin by Mr. and Mrs. Herbert Hoover. Agricola, after saying that the virtues of the divining rod are subject to much dispute, and stating both sides of the dispute with admirable clearness, proceeds to assert that the diviners, or dowsers, although they sometimes succeed in discovering veins, quite as frequently fail, and like other people, have to dig if they wish to find anything. Wherefore, he advises the respectable and sober miner to study the indications of nature and then dig at once without further fooling. A quaint woodcut accompanying this passage depicts a miner cutting his hazel twig from a bush and another wandering with it over the hills in search of metals.

Notwithstanding the wise advice of Agricola, the belief in the efficacy of the divining rod was widely held in the eighteenth and nineteenth centuries. Volumes were written upon it, and many new semi-scientific reasons were advanced for its occult powers. Raymond states that many water wells were being located in New England in the middle of the last century by means of the divining rod and that numbers of wells were being bored for oil in Pennsylvania at points designated by the manipulators. To the geologist, the divining rod is a thing of the past; he believes it is used only by persons who fool themselves or desire to deceive others. But old beliefs die hard; Mr. Rickard states that in June, 1926, the municipality of Bombay appointed an official "dowser." Throughout rural regions they are frequently met with today, and nearly every year someone turns up in Kirtland Hall to inquire if they can be depended upon to find water upon his land.

The Call for Modern Divining Rods.

The ever increasing demand of this Machine Age for the useful minerals has spurred on the search for new deposits of metals and petroleum. Petroleum companies have extended their operations to new fields in the hope of finding more oil pools to replace waning ones, and they have done it all too successfully for the oil industry; mining companies have been exploring new fields intensively and have been carrying on vigorous development programs in their existing mines. In most cases the rewards have in the long run justified the search. But as the valuable deposits discovered by surface evidence alone are becoming exhausted, and the most easily explorable places have been eliminated, discoveries have become fewer and the expense of exploration has mounted higher and higher. The economic geologist has been called upon more and more to bring to bear his knowledge of rocks, minerals, and the occurrence of ores, in this search for new deposits, and he now plays an important part in the mineral industry. But many things lie hidden beyond his direct observation, and expensive test boring and digging are necessary. Such work more often than not is only a failure chargeable to the cost of exploration, and is an anticipated risk taken by exploration companies.

Herein lies the demand for the modern divining rod—to yield more precise information regarding those things beyond the direct observation of the geologist and miner. If geophysical methods can be utilized to indicate the presence underground of mineral bodies, or of geological conditions favorable to the presence of valuable mineral substances, then much initial exploration can be eliminated. However, geophysical methods do not discover mineral bodies, they only indicate the presence of

something that may or may not be valuable, and actual testing by boring or digging is still necessary. But they can perform an important service in eliminating places that otherwise might be tested, and in confining attention to the places of greatest promise. It is in the search for mineral deposits in virgin ground that geophysical methods stand pre-eminent. On a surface covered by soil, where there is nothing to guide one as to hidden deposits, a scientific divining rod may single out of the wastes a place where lies a body of material that is essentially different from the surrounding rocks. Thus mineral bodies, salt domes, rock structure, and depth to bedrock may be indicated. It is obvious that any method that can accomplish such results will find a ready place in the present-day application of science to industry and will create a following as great, if not as credulous, as that of yore which believed so blindly in the divining rod.

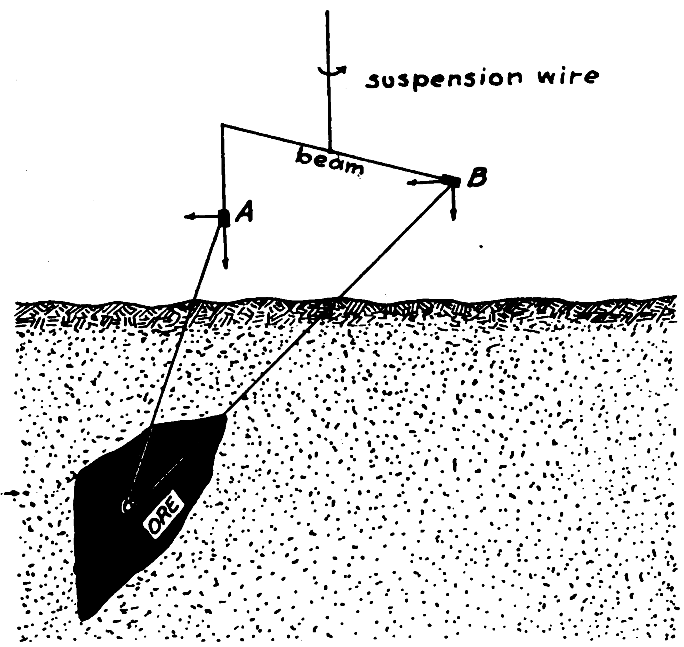

FIG. 1. *Diagram of Eötvös torsion balance with a heavy mineral body attracting the weights A and B and twisting the suspension wire above the beam.*

But just how may mineral bodies be detected by geophysical means? The methods depend upon the differences between rocks, ores, and soils beneath the surface. The physicist creates some kind of an effect which penetrates into the ground and is distorted and reflected when it meets boundaries between different substances. In other words "he sends a message down and the rocks and ores send back signals in reply." The physicist must figure out the kind of message to send down, and the physicist and the geologist must be able to interpret the replies. In some cases no messenger is needed, for Nature supplies one in the terrestrial magnetic field which automatically and continuously conveys messages from beneath. Or there is the earth's gravitational field which conveys messages. In other cases it is necessary to use an outside energizing force to stimulate the orebodies to a reply. Thus different methods and instruments are employed, depending upon which principles are utilized to send the messages and receive the replies.

The Modern Divining Rods.

The modern divining rods are designed to take advantage of those natural characteristics within the ground that may have value in indicating the presence of mineral, and to create artificial energizing forces and again detect them after they have been modified by geologic boundaries. Within the last few years they have been developed apace. Regularly established companies now carry on, for large fees, geophysical prospecting for mineral substances. Although the subject is in its infancy, notable mineral discoveries have acted as a spur to stimulate new endeavors. Vigorous research is being carried on and new instruments and better methods are resulting. A voluminous literature has sprung up, and courses of study in geophysics have already been established in two American colleges.

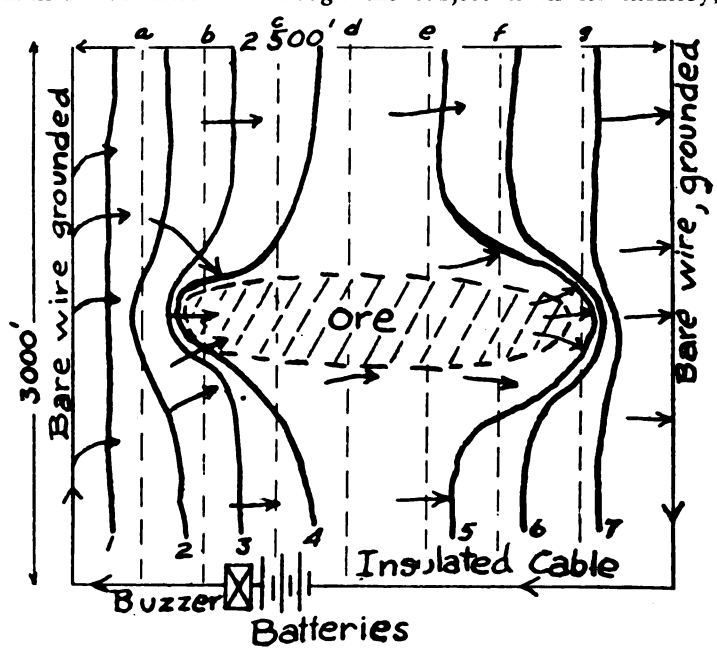

FIG. 2. *Diagram of an area showing results of a survey by equipotential method, using line electrodes. Direction of the flow of electrical current from one grounded wire to the other is shown by arrows. Measurements are not made of the electrical flow, however, but of the lines of equal electric pressure or potential. Dotted lines a, b, c, etc., indicate position of equipotential lines if no disturbing body were present, Solid lines 1, 2, 3, etc., show position of measured equipotential lines that indicate presence of conducting orebody as shown.*

The new geophysical methods are not so simple as the use of the forked hazel stick held in the hand. The instruments are complicated and expensive; their use necessitates a detailed knowledge of physics, mathematics, and geological interpretation. To explain them in detail would prove boresome reading to the perusers of this Magazine. Consequently, I shall outline only briefly, in non-technical language, the methods and instruments used and the results attained by them.

The Methods Used.

The geophysical methods now employed fall into four groups:

A. Gravitational.
B. Electrical.
   1. Equipotential.
   2. Electromagnetic or Inductive.
   3. Spontaneous polarization.
C. Seismic.
D. Magnetic.

A. *Gravitational Methods.* This method makes use of the earth's natural gravitational field. Everyone knows, of course, or should know, that any body exerts a gravitational pull which rapidly decreases as distance from the body becomes greater. The heavier and the larger the body, the greater the pull. The largest body with which we are familiar, of course, is the earth, and because of its gravitational pull the apple that falls from the tree drops straight toward the center of the earth until arrested by the ground. But smaller bodies likewise exert a gravitational pull. The denser the body, the greater the pull it will exert for its size. The suspended plumb-bob is supposed to point directly toward the center of the earth because of the earth's gravitational pull, but if a large, heavy body lies to one side of it, the plumb-bob will not hang vertically but will be pulled slightly toward that heavy body because of its gravitational effect. This principle is so well known that in the precise surveying of this continent the United States Coast and Geodetic Survey has to subtract the gravitational pull of any mountain that may lie to one side of their plumb-bobs, otherwise they would not have a true vertical, or a true level from which to measure vertical angles to parts of the earth's surface or to the heavenly bodies.

If the direction and amount of the deflection can be determined, then the position and mass of the attracting body can be calculated. And herein lies a principle upon which one type of divining rod is devised. The heavy attracting body may be an ore deposit consisting of metallic substances heavier than the surrounding rock, and the simple plumb-bob becomes a complicated instrument which records the direction and amount of pull of the attracting mass. Baron Eötvös of Budapest first devised such an instrument to measure the earth's gravitative pull.

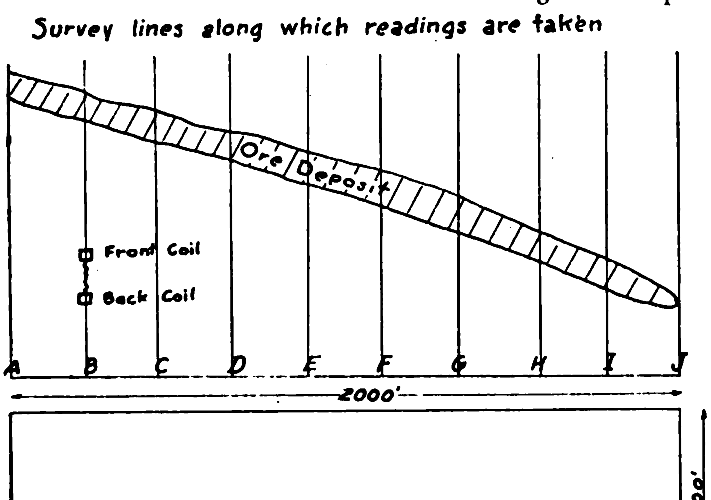

Fig. 3. *Diagram illustrating the layout for an electro-magnetic survey.*

Later it became adapted to detect bodies in the earth of different weight (specific gravity) than the surrounding rocks. If this instrument is set up above material that is uniform in density on all sides of it, it gives no response; but if there is an excess or deficiency of density on one side or the other, it becomes unbalanced. It is so sensitive that if a man stands near it, it is deflected, and by the amount of its deflection the man's weight can be calculated. I actually had my weight so calculated at a laboratory in Germany. Moreover this divining rod twists horizontally toward the man's mass and so indicates his position.

The instrument in essence consists of a horizontal beam suspended upon a delicate platinum-iridium thread. Upon one end of the beam is a gold or platinum weight, from the other is suspended another similar weight. (See Fig. 1.) If then the instrument is set upon the ground and an ore deposit of heavy metallic substances lies beneath and to one side of it, both the vertical and horizontal weights are attracted toward it, and the beam also twists on its delicate suspension wire in the direction of the attracting mass. This remarkable divining rod thus indicates the general direction of the hidden orebody. The twist or torque on the delicate suspension wire has been very carefully determined so that from the amount of this twist the direction and distance of the mass of the attracting orebody can be calculated, provided its specific gravity be assumed. If, however, the instrument is set up in several different places, the results when plotted will point both horizontally and vertically to the center of the attracting orebody. The position once ascertained, the attracting mass can then be explored to see of what it is composed.

Fig. 4. *Instruments used in the electro-magnetic method for the detection of induced currents. (Swedish-American Prospecting Co.).*

The instrument is so sensitive that it detects changes in the order of one part in a million million. Its very sensitiveness is in a way a drawback, for it has to be set up in a three-walled tent to shield it from atmospheric changes; the ground near it has to be leveled of all protuberances that might attract it; and the mass of nearby hills has to be calculated and their attractive pull deducted from its readings. The calculations are involved and difficult and the corrections are important. The final interpretation of results presents a difficult problem to the geologist and physicist. Nevertheless one hundred or so of these costly (from \$10,000 to \$30,000) instruments have been purchased for oil prospecting in North America. They have de-

tected the difference between limestone and sandstone strata, and have led to the discovery of several salt domes, and in turn to oil pools commonly associated with salt domes. They have not been used so extensively for metallic deposits as for petroleum, since metallic ores commonly occur in rough topography where the sensitivity and weight of the instrument render it less usable. It is best adapted to flattish regions. It detects with considerable precision the differences in the specific gravity of salt, ore, gravel, and bedrock, and has been used to locate the depth of bedrock.

B. *Electrical Methods.* These methods are now the most widely used for the detection of metallic mineral bodies.

1. The *Equipotential method* is one of the simplest. Several modifications are in use. The procedure of one of these is as follows: Two parallel bare copper wires stretched over the surface and grounded at intervals, form electrodes, and are supplied by current from storage batteries with a high frequency buzzer attached. (See Fig. 2.) Current passes through the ground from one electrode to the other. If the ground between the electrodes is of uniform conductivity, then lines of equal electrical pressure or potential will be parallel to the bare wires, as shown by the dotted lines a, b, c, etc., of Fig. 2. However, if there should be present a mineral body that is a better conductor than the rock, the lines of equal potential will not be straight but will be distorted by the conductor, as shown by the solid lines (1, 2, 3, etc.,) of Fig. 2. Therefore, the problem of detecting the mineral body is to determine these lines of equal potential. This is done readily: An assistant sticks a steel rod in the ground; it is connected by a 30-foot insulated wire to the operator's steel rod, to which are attached ear phones. The operator sticks his rod in different places until he hears no buzz in the ear phones, then he knows the two rods are on a line of equal potential. These points are marked with small stakes, and the lines of equal potential are thus marked out and later surveyed.

Many valuable deposits have been found by this method. In Sweden, where the method has been perfected, several valuable copper deposits have been detected in places where their presence was entirely unsuspected. An amazing discovery was recently made in Newfoundland. Digging was started where the distortion of the equal potential lines indicated an underground conductor. The first shovelful of soil disclosed a lead-zinc-copper deposit beneath. A railroad has been built to it, and a rich and valuable mine is being opened up.

2. The *Electromagnetic* or *Inductive* method utilizes a huge rectangular loop (Fig. 3) of insulated wire through which is passed an alternating current of high frequency (500-1,000 cycles). This penetrates the rocks and soils nearly as readily as it does the air and sets up an induced current in the ground. If a conductor, such as an ore deposit, is present, a new magnetic field, called the secondary induced field, of the same frequency is emitted by the conductor in all directions. It is this secondary field that is desired to be measured, and its detection indicates the presence of an ore deposit. However, both the primary and secondary fields must necessarily be present at the same place. Consequently, by means of suitable instruments, the total is measured, and from it is subtracted the amount due to the primary field, which in turn is obtained by calculation for each point of observation. The residue gives a measure of the strength of the secondary induced field. If this is large, it indicates that the disturbing orebody is a large one or else close to the surface.

There are of course many ways of carrying this out in practice. One procedure is to survey parallel lines at right angles to the longer dimensions of the rectangular loop (Fig. 4). The observer walks along these lines taking readings at intervals of about forty feet. As he departs from the loop whence the primary field originates, the measurements grow weaker and weaker but if he approaches a hidden ore deposit the measurements increase (due to the secondary field), approach a maximum immediately above the margin of the ore deposit, and fall away again as the farther margin is left behind. Similar measurements on other parallel lines will indicate the extension of the ore deposit and thus its size and boundaries may be approximately outlined. The measurements are made by means of horizontal and vertical coils which may be seen in Fig. 4.

This inductive method is the most precise of the electrical methods and creates the strongest energizing field in the ground. It is used also as a check upon findings made by other electrical methods, for it indicates with greater precision the shape, size, and position of orebodies. It is a true divining rod. It can be used where the equipotential method cannot, since it does not depend upon grounded electrodes. It is adaptable to use on rocky ground, in barren mountainous regions, on dry sand or gravel, or on ice-covered lakes or deep snow.

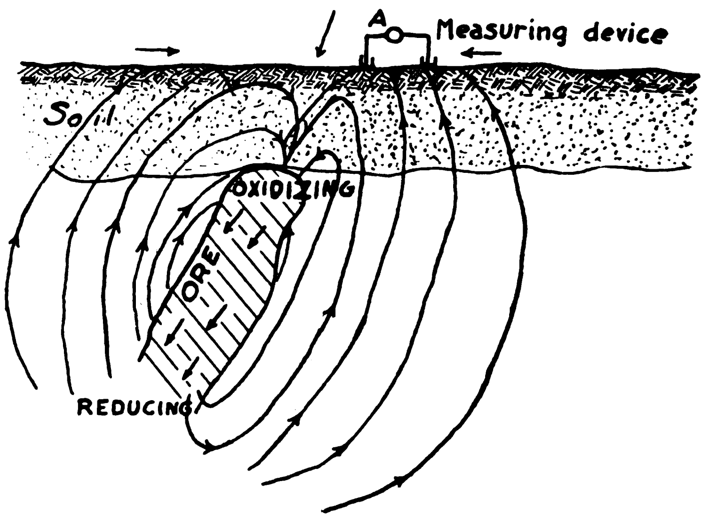

FIG. 5. *Diagram illustrating sulphide orebody acting as a battery with current lines, shown by arrows, flowing through and around it. The detecting electrodes and galvanometer are shown at A.*

3. The *Spontaneous Polarization* method requires no outside energizing force. It is used to detect natural currents in the ground that originate because of differences in the state of activity of the upper and lower parts of an ore deposit. Rain water oxidizes the upper part of an orebody more than the lower part. Electrical currents, therefore, flow naturally and continually from the bottom of an ore deposit through the surrounding rock to the top, completing the circuit through the ore deposit itself (Fig. 5). By tracing such currents ore deposits may be found. This is done by placing two rods on the earth and connecting them with a sensitive galvanometer. Thus a survey may be made of the lines of equal electric pressure or potential. If an ore deposit is present it will be surrounded by lines of equal potential. This scheme is delightfully simple, and under favorable conditions works well in locating some orebodies near the surface. It is obvious, however, that it has little application in arid regions where the ground water is deep or absent.

(*Continued on page 35*)

Managing Men as an Engineering Problem

Yale's Course in Personnel Administration Gives Students Training in the Handling of Men, the Biggest Problem Confronting an Executive.

By Professor Elliott Dunlap Smith

OVER seventy-five per cent of all engineers become executives. This condition, disclosed by the recent Investigation of the Society for the Promotion of Engineering Education, was the same a quarter of a century ago, when Cornell and Lehigh each made similar surveys.

Today, the distinguishing characteristic of an executive is that he is a man who manages men. Especially in manufacturing, which is the field where most engineers become executives, ability to handle men has become important. Throughout the past two generations the development of manufacturing technique in regard to machinery, materials, and process, has exceeded the development of ability to handle people. Moreover, the growth in size and complexity of manufacturing companies and the increase in specialization of labor and functionalization of management has complicated the relationships between executives, as well as those between management and workmen, and made the personnel problems of the executive as difficult as they are important.

Business men are seeing this situation with increasing clarity. Even the banker, who is interested directly only in the financial aspects of business, but is in a position to see business in action—not only one business, but that variety which makes up our economic life—is calling attention to the key position in industrial success of sound management of the human side of a business. For example, Mr. O. H. Cheney, Vice President of the American Exchange-Irving Trust Company of New York, said last November to an informal conference on engineering education called by Dean Kimball of Cornell: "Sound management must include not only the management of machines, materials, methods, and money but also the management of men. I stress men because time and again I have seen otherwise good management fail in its administration of personnel relations. Good machinery, good technical methods, intelligent financing, energetic selling—I have seen all these turned to naught by poor management . . . Real knowledge of sound management principles as applied to personnel relations must be a part of every executive's equipment and the daily practice of them a vital part of every executive's functions—from the chairman of the board of directors down to the youngest straw boss."

The Importance of the Problem.

Although many concerns, including banks and stores as well as factories, recognizing the importance of good personnel management, have installed specialized personnel managers, experience has everywhere proved that this does not in any way remove from the operating executive the importance of skill in handling men. Few of the relationships of men and management, or of one executive with another, can be set apart for special treatment, as can the problems of facilities, or process. Personnel policy is inextricably interwoven with executive policy, and personnel skill is an inseparable element of executive ability. Even engineering proper is now recognized as involving the task of managing men to such a great extent that the definition chosen to be put over the door of the United Engineering Societies' Library in New York reads, "Engineering *is the art of organizing men* and controlling the forces and materials of nature for the benefit of the human race."

The importance and difficulties of skillful management of personnel have been born in upon me by my own executive experience. My work has largely consisted of reorganizing departments and branch factories. In doing this I found in every case that my principal problem was to find satisfactory executives. Once I had found the right executives, it was relatively easy to work out the other problems. In seeking executives I tried out engineers, college graduates, and men who worked their way up through the shop without public school education. In every case I found technical knowledge at a discount. It was relatively easy to get. But the thing that I could rarely get ready-made was technically qualified men who knew how to handle men—not "personnel men" in the sense of employment or personnel managers, but men who, in their executive contacts with people, understood them and could get results because they understood. On the other hand, I found that while the men who were already skilled in managing men were rare, astonishing improvement could be made through training. This somewhat narrow experience of my own has been confirmed again and again by leading executives. From such widely different experiences as those of Mr. Gano Dunn of J. S. White & Company, Col. J. P. Jackson of the New York Edison Company, and Owen Young of the General Electric, for example, public statements have recently been made of the great difficulty of securing men with technical training who are qualified to organize or command enterprises.

The mere fact, however, that ability to handle people is of such great importance to the seventy-five per cent and more of engineers who become executives, does not imply that such ability can be provided by undergraduate courses. Much of any man's ability is not acquired in school, but from experience. "Why cannot the engineer pick up the principles of personnel management as he goes along?" was a question raised by Mr. Cheney in the conference to which I referred, and he added, "The answer is the question: 'Is he expected to pick up the principles of engineering as he goes along?' He should learn in school to recognize the stresses and strains in management as well as in machines and materials." Of course, the capacity to acquire skill in human management, as the capacity to acquire skill in engineering research, depends largely upon deep seated traits, but in both cases these traits are of relatively little value unless they are developed. Moreover, engineers are trained to be precise in the mechanical sense. Because engineering is a mature and precise science, engineering undergraduates study almost wholly principles that are subject to mathematical manipulation. But in almost all personnel situations there is no possibility of being precise with an exact mechanical precision and there are no answers which can be manipulated or even stated mathematically. Although there is a growing body of fundamental principles and tested practice, because of the subtleties of human nature the same thing done by one man or by another will produce a good result or a bad, depending on how each one does it. Accordingly, it is of especial importance to provide engineering students, whose

training inevitably emphasizes the technique of materials, mechanism, and process, with an adequate appreciation of the individual and collective human problems of industry.

Proper Attitude Necessary.

On the other hand, merely to give students personnel facts or what are ordinarily termed "principles" does not give them adequate personnel preparation for executive work. More than information or precepts, students need to gain from their training a proper attitude and a method of approach toward problems involving human nature. I mean by attitude that point of view towards their work which causes executives to look for and appreciate the human aspects and values in their problems—that makes them sensitive and speculative in regard to human relationships. I mean by method of approach habits of mind that will enable executives effectively to analyze whatever problems may come to them so as to bring out and evaluate their human elements and thus to act in understanding conformity to the demands and qualities of human nature. Neither attitude nor method of approach comes from information. We can pour a mass of personnel information into a student's mind, and even have him retain it; and yet not have him get from that information either personnel attitude or personnel ability. Instead, the student needs experience with actual situations as closely as they can be produced in the class room. By puzzling over typical situations, he will acquire that sensitiveness to human problems that will cause him to recognize these problems in the situations he later encounters in the practice of his profession. By comparing the solutions that he finds with those of his colleagues and instructors, he will develop a recognition of the elements that successful management of men involves. By working upon these problems under the competition of his colleagues and the guidance of his instructors, he will develop a method of dealing with such problems that will give him dexterity and comprehensiveness in reaching his own conclusions. And, in addition, in handling such problems he will amass an understanding of present day personnel practice and principles, not as exact answers to problems, but as a growing, changing background against which his own conclusions can be more clearly formed. If students are thus taught to recognize the human problems involved in their work, and given some experience in finding their way to solutions of such problems, their future experience will no longer be "hit or miss." Just as with their technical training, such personnel preparation will cause experience in actual life—failures as well as successes—to contribute in an orderly and effective, instead of a desultory, way to the accumulation of understanding and ability as they progress in the practice of their profession.

To meet these conditions of preparation of engineering students to acquire ability to handle men, Yale has taken definite steps. Yale was among the leaders in establishing a course in Industrial Engineering, and is almost alone in constituting this course a direct preparation for executive duties, instead of a course which develops specialists in such manufacturing techniques as planning control or time and methods study. To this end, in addition to a thorough grounding in engineering and in the engineering aspects of management, the curriculum in Industrial Engineering has from the start emphasized both general and applied economics, and has included a course in Personnel.

Yale's Solution of the Problem.

This year, better to prepare these Industrial Engineering students for the problems of human management which bulk so large in the executive work, funds have been made available that make it possible to carry out plans of long standing for the extension of personnel training. The two-hour course in Personnel for one half year has been made a three-hour course for the entire year. The study of the technique of personnel administration has been made subordinate to the study of actual industrial problems and these problems are made as real to the students as possible. For example, one problem sometimes used is this: "Assume that you have just been hired for your first job and made the 'runner' for the foreman of a cutting room in a box shop. The foreman brings you a bunch of box forms and says, 'You see that man over there? He is one of our most skillful cutters, but he made an error of 1-64 of an inch in cutting these forms. You go over and tell him to trim these forms down so they are right.' What would you do?" When the problem comes up for discussion, the instructor says to some student, "Assume that I am that man. You tell me to cut this off." And the student tries to tell him. For instance, a student may say, "Won't you cut that off? You cut them 1-64th of an inch too long." To which, the instructor might say, "Who are you to tell me how to cut these forms? I have been here for 15 years and you have been here less than 15 days." And then turn to an imaginary colleague and say, "Do you see that little smarty? He thinks he knows how to tell me how to cut forms!"; and then ask the student, if that happened what he would do next; and after this student and others have done their best, the class talks over the good and bad points and why they were good or bad. These problems are arranged so as to give a systematic presentation of the psychological factors involved in the interrelations of people in organized work. They are also selected so as to cover the principal sorts of personnel situations which a student is likely to encounter from first going to work in an industrial or business organization, through those that he must face as he works up to positions of managerial and executive responsibility.

The Course.

During the first term students are required to prepare a psychological study of some problem of organized human relations with which they have had direct contact. During the second term, the students who desire to work for an honor grade in lieu of assigned reading, are required to write a thesis either upon some major personnel problem, such as the relationship of employee representation to trade unions, or upon the personnel aspects of some specific situation, such as the reorganization of some particular factory. Technical personnel information is acquired primarily through reading, but is made real through the incidental side lights that the class problems throw upon it. While the methods of functionalized "personnel management," and the major problems of the relation of capital and labor are discussed, the less formal personnel problems that arise in conduct of his job by an executive, are emphasized. For the primary aim of this course is to equip the students to recognize the personnel problems which are involved in the situations that they will encounter in actual life, and to provide them—through practice—with a method of approach to these problems, that will assist them in reaching their own solutions.

Industrial Engineering students, in spite of the broadening of the curriculum, study principally courses dealing with inanimate things with mathematical precision. Their economic courses, although not dealing with physical data, deal primarily

(Continued on page 37)

Yale-British Excavations in Trans-Jordan

Unearthing the Graeco-Roman City of Gerasa Which Dates Back to New Testament Times

By Professor B. W. Bacon

YALE UNIVERSITY has recently taken an appropriate part in the fast developing field of classical and Byzantine Archaeology wherein Princeton has hitherto been the leader among American institutions. One reason has been the calling of Prof. M. I. Rostovtzeff, one of the foremost authorities in this field, to a Sterling professorship of Ancient History and Classical Archaeology. Another has been the splendid development of the Yale Art Museum under the direction of Dean Everett P. Meeks, where Curator Sizer has found place for a great store of material already in hand unknown to the general public. Visiting alumni have recently had occasion to observe to their great surprise that already new space is required to exhibit archaeological material from Egyptian and Babylonian antiquity down to Graeco-Roman, Byzantine and Early Christian times, over and above the well known collections of medieval painting and sculpture. A third reason for Yale's entrance into the field particularly of classical, Early Christian and Byzantine archaeology is the opening of the Near East under French and English control as a sequel of the Great War to archaeological research to any extent that funds and competency will allow. Thus, through cooperation with the French Academie des Inscriptions, under whose auspices M. Franz Cumont, a recent Silliman lecturer at Yale, has lately been uncovering magnificent remains of the Seleucd and Graeco-Roman city of Doura-Europus on the Euphrates, and by aid of an appropriation of $75,000 from the General Education Board, Prof. Rostovtzeff, as Yale's representative, has been able to assume responsibility for carrying

FIG. 1. *Gerasa—The Nymphaeum from Southeast on Main Street.*

onward for three additional years the fruitful excavations of the French, destined otherwise to be abandoned for lack of funds. Another much smaller project, but in proportion not less fruitful, is just about to enter upon its second year at Jerash in Transjordan ("the city of the Gerasenes" in the Gospel of Mark), where Director J. W. Crowfoot of the British School of Archaeology in Jerusalem remains in principal charge of the excavations, while Yale University, through the liberality of a large number of contributors of small amounts, defrays the major part of the expense and is represented on the archaeological staff.

The Ancient City of Gerasa

Gerasa in New Testament times was the greatest and richest of those "cities of the Gentiles" which since Alexander's

FIG. 2. *Gerasa, Basilica of St. Theodore. Lead pipe from water main to fountain in Fountain Court.*

conquests had been a thorn in the side of Jewish nationalists, but the greatest instrumentality of Seleucid, Greek and Roman statecraft in promoting trade and civilization on the eastern borders of the Empire. It formed an important trade and banking station on the great caravan route between the Nile and the Euphrates valleys, midway between Petra and Damascus. Its nearest neighbor on the south was Rabbah of Ammon, besieged by David's troops under command of Abner, when the faithful Uriah the Hittite, husband of Bathsheba, was betrayed to his death. This ancient site, rebuilt and fortified against incursions of Bedouin marauders by Ptolemy Philadelphus c. 280 B. C. and named from him Philadelphia, was granted as a concession for excavation to Italian archaeologists by the enlightened Emir Abdullah in the same year (1928) that Yale received that of the far more promising site of Jerash. Excavations were begun at Amman under royal auspices only a few weeks after the Yale-British expedition had begun its work at Jerash under patronage and protection of Mr. Geo. Horsfield, British Director of Antiquities under the Emir.

The earlier history of Gerasa is unknown. It was always, next to Damascus, the most important link (in a commercial sense) in the chain of Greek cities along the great caravan

route, but stood a little inside the chain of military posts by which Trajan and Hadrian protected it. The road ran somewhat east of north from Philadelphia to Bostra, both of these having strong Greek, and subsequently Roman, garrisons. The more direct and better protected line of travel passed through Gerasa and Pella. Roman detachments (vexillationes) had comfortable quarters at Gerasa, built their shrines and theatres there with appropriate inscriptions, usually in Greek but sometimes in Latin, and recruited there both men and horses for the legions. The horses in particular were famous. They constitute to this day the noted "Arab" stock, and were raced in Gerasa's superb hippodrome. Undoubtedly the magnificent water supply, irrigating all the surrounding valley, and conducted in a system of lead pipes, the mains of 14 inches interior diameter, throughout the principal streets, baths, fountains and public buildings of the city, must have occasioned the occupation of this rich site from earliest times. But history does not yet exist for the earlier occupation. Not even the derivation of the name Gerasa is known. Only Josephus tells us of the proud boast of Alexander Jannaeus, Jewish nationalist and Hasmonean king, of his conquest of the city in the wars of reaction against the attempt of Antiochus IV (Epiphanes) to Hellenize Palestine by force. This was about 100 B. C. Pompey, in 63 B. C. restored to these Greek cities their former independence, so that the era which all adopt in their numerous inscriptions dates from this year of independence and is called the Pompeian Era.

FIG. 3. *Gerasa—Fountain Court of Martyrinne. Basilica of St. Theodore.*

Only further excavation can reveal the earlier history of Jerash, for excavation necessarily proceeds from the top layer, which in this case is Early Christian, the site having been finally abandoned soon after the Arab conquest in 631. But the great public buildings whose columns and arches still protrude above the piles of debris and desert soil inform us by their wealth of inscriptions of the date of the city's greatest prosperity. Its great central temple of Artemis was built in the 22d year of Tiberius (A. D. 7) and from this date throughout the period of the great emperors it flourished and grew for two centuries.

Reading History on Inscriptions

The relation of the city to Jewish history is indicated by two groups of inscriptions, both belonging to periods of vital interest for the history of Jerusalem, and both due to the presence of Roman troops quartered here on a convenient station on the great route from Egypt, the region whence they were recruited. An inscription recording the building of the superb colonnade around the temple of Artemis and the pool or basin within, tells of its completion in 69 A. D., the very year of the siege of Jerusalem, when the accession of Vespasian to the empire was still a matter of doubt, as some features of the inscription suggest. The colonnade of 250 stone pillars rivalling the finest of our own city gives some indication of the enormous riches lavished on the town of not more than 60,000 inhabitants. In addition a wealthy veteran of this same campaign contributed a row of seats to the larger of its two theatres seating (in numbered reserved seats) nearly 5,000 citizens. The troops belonged to the Third Legion, called Cyrenaica, from the region where it was recruited. In 106 A. D. its headquarters were at Bostra, a day's march nearer Damascus and on the actual frontier; probably the officers found pleasanter quarters at Gerasa, where they dedicated a shrine to Serapis, the Egyptian equivalent of Jupiter. Corroboration comes partly from Josephus, who in his history of the Jewish War (II, 18, 8) tells of the aid given by this legion in the suppression of a Jewish revolt in Alexandria in 67 A. D. and subsequently of the distinguished service rendered by a detachment of 1,000 of this same legion in the siege of Jerusalem in 69-70. Still more striking, however, is the evidence of another inscription set up by this same legion in honor of this same divinity (Jovi Optumo Maxumo Sarapidi) in Jerusalem itself, where it was discovered in 1894 in perfect condition. The date of the Jerusalem inscription, however, is under Trajan, when, as we have said, the headquarters of the Cyrenaic Legion were at Bostra. Manifestly rebuilding was in progress in Jerusalem itself at this time, and the Roman troops from Egypt were taking part in it.

FIG. 4. *Gerasa—Site of the Yale-British Concession from Temple of Artemis Looking Southeast.*

Not less interesting to the student of Jewish history is the period of the last and most desperate revolt of all under the messianic leader Bar Cochba, when the great rabbi Akiba went to martyrdom in its support. The revolt was provoked by the determined effort of Hadrian, who in 130-132 accompanied his troops to Palestine, travelling as far south as Petra and thence to Egypt, to carry out the traditional Roman policy of

(*Continued on page 35*)

The Pigments Present in Green Leaves

The Chloroplasts Occurring in Plants have Important Theoretical and Practical Aspects.

By Dr. Carl G. Deuber

THE pigments responsible for the green color of plants constitute a most important chapter of biochemistry and plant physiology. These pigments enter into consideration in practically every phase of the plant sciences from their occurrence in the organized protoplasmic structures (chloroplasts) in green cells, to the shape and arrangement of leaves for effectively carrying on the synthesis of carbohydrates in the presence of light. Numerous conditions of malnutrition and parasitic attack of the higher plants are first made evident by a yellowing, mottling or other disturbance in the normal green foliage. Aside from the importance of the leaf pigments to the proper functioning of plants they appear to be associated with the parts of plants high in vitamine content and have many uses in the industries. While the importance of the leaf pigments is realized by most plant investigators there are relatively few laboratories carrying on research with them. During the past four years a series of studies on the biological aspects of these pigments have been under way at the Osborn Botanical Laboratories.

Cause of Green Color

The normal green color of plant leaves is due to the presence of four pigments in the chloroplasts where they are formed and function. Two of these are green, chlorophyll *a* and chlorophyll *b*, and two are yellow, the carotinoids, carotin and xanthophyll. From the nature of their occurrence they are known as the chloroplast or plastid pigments to distinguish them from the red, blue or yellow pigments that occur in the sap of the cells of some leaves and in the petals of flowers. The multiplicity of the plastid pigments was first correctly demonstrated by the physicist, G. G. Stokes, in 1864. Stokes also noted the strong red fluorescence of the green pigments. For over thirty years after Stokes's observation various investigators ascribed the green color of leaves to one pigment or to a number of poorly defined pigments. It was not until the brilliant work of the organic chemist Richard Willstatter, beginning about 1906, that the chemistry and physical features of the plastid pigments became known with any degree of accuracy. At the present time it is stated that the chemistry of the plastid pigments is as well understood as that of any other plant products.

An early observation of the failure of chlorophyll to develop when iron was withheld from seedlings led to the contention that iron was present in the chlorophyll molecule. An analysis of the green extract of leaves by one investigator indicated the presence of phosphorus and potassium. Willstatter found magnesium to be the only mineral element present in the chlorophyll molecules and assigned the formula $C_{55}H_{72}O_5N_4Mg$ to chlorophyll *a* and $C_{55}H_{70}O_6N_4Mg$ to chlorophyll *b*.

One of the factors accounting for the success attained by Willstatter in this field of plant chemistry was the large scale methods employed. Leaves were brought into the laboratory in wagon loads, the extraction processes requiring many liters of organic solvents and specially designed apparatii. The value of such a procedure is evident when it is known that a ton of fresh leaves yield approximately 4 lbs. of chlorophyll *a*, 1½ lbs. of chlorophyll *b*, 1/3 lb. of carotin and 2/3 lb. of xanthophyll. In one experiment the yolks of 6,000 eggs gave 4 grams of crude xanthophyll.

It was found that the plastid pigments of all plants examined were identical and that a fairly constant relation exists between the quantity of the chlorophyll components *a* and *b* and between carotin and xanthophyll in normal plants. But the ratio between the chlorophylls and carotinoids varies widely in different leaves and during the year. In autumn the chlorophylls decompose while the carotinoids remain. This partially explains the yellow color of autumn foliage.

At the present time the part played by the plastid pigments in the process of photosynthesis is not known with any degree of completeness. This most fundamental process by which the green parts of plants in the presence of light are able to synthesize carbohydrates from water and carbon dioxide has occupied the attention of botanists and chemists for years. There are numerous theories on this process but none have given sufficiently adequate explanation of the photochemical and chemical mechanisms and reactions involved to receive general support. It appears that the chlorophylls are not decomposed during active photosynthesis and that there is no appreciable conversion of one pigment into another. Some theories assign a part to the carotinoids while others leave them out of consideration.

Geneticists have worked out the inheritance of various chlorophyll patterns in a number of plants. With corn this type of work has been very extensive. Strains of corn are catalogued which on germination segregate seedlings which are pure albinos, dying after the stored foods in the endosperm are exhausted. Other strains yield white or faintly yellow types which later develop the normal green pigments, others produce various types of striping, green stripes alternating with white or yellow stripes. When the non-green areas are large in proportion to the green areas of the leaves the photosynthetic process is reduced and the plants may be small and less vigorous than green strains.

Light Essential to Chlorophylls

Light is essential for the development and functioning of the chlorophylls although if the light intensity becomes too great these pigments are destroyed. The decomposition of the chlorophylls is desirable in some cases. The skins of a number of fruits develop the chloroplast pigments and carry on a limited amount of photosynthesis. Some varieties of oranges, particularly the Satsuma, develop their full food value and sugar content long before the peel loses its green color. Since the housewife does not realize this fact green oranges do not find a ready market. The delay necessary for the green pigments to decompose while the oranges are on the trees hinders the growers from receiving the high early market prices. It has been found that treating such ripe but green-skinned oranges with low concentrations of ethylene gas, the fumes from gasoline stoves or gasoline engine exhaust gas decomposes the green pigments. It is maintained that the food value of the fruit is not injured by this process.

Green lemons have been treated in this manner since 1912. Green tomatoes, bananas and other fruits have been treated with gas as well as the blanching of celery in carload lots.

Various mineral elements must be taken up by plants in order that the chloroplasts form the pigments and maintain them in a functioning condition. A deficiency of iron is very readily observed. The foliage becomes chlorotic, yellow-green to pure yellow and in some cases white in color. In some of the highly calcareous soils of Hawaii the iron in the soil though abundant is precipitated due to the alkaline nature of the soil water and is therefore not available to plant roots. Pineapples to be grown successfully on such soils are sprayed several times during the growing season with a dilute solution of ferrous sulphate. The copper of Bordeau mixture, a fungicide spray, increases the chlorophyll content of sprayed leaves. A deficiency of nitrogen causes the foliage of plants to become a light green or yellow color while an ample supply of this element produces dark, green leaves. In some Kentucky soils, a deficiency of magnesium causes tobacco plants to become chlorotic. On some soils, additions of manganese have been found to restore the normal green color of various crop plants. Abnormal features of the mineral nutrition of plants are rapidly reflected in the degree or quality of color in leaves. Several diagnostic tables of physiological plant maladies have been constructed on the basis of leaf color characteristics.

Chlorophyll Damaged by Parasitic Diseases

A large number of parasitic diseases of plants result in abnormal chlorophyll conditions. One of the most interesting of these is the mosaic virus disease of tobacco. The large leaves of the tobacco plant become mottled with light green and dark green areas. Mr. A. A. Dunlap of this laboratory has followed the chlorophyll contents of normal and diseased leaves throughout the growing season. The results of this investigation show clearly that the virus distinctly affects the chlorophyll apparatus of the leaves from a few days after infection to the end of the season. A rather constant reduction of green pigments as compared with healthy leaves occurs during the first fifteen weeks of infection. Up to this point, the leaves appear to hold the attack upon the chlorophyll apparatus somewhat in check, but during the following five weeks, the chlorophyll content of the diseased leaves declines, while in this same period, the chlorophyll content of healthy leaves increases at a surprising rate.

To turn aside from the purely biological aspects of the leaf pigments, it is possible to indicate a variety of uses to which these pigments or a knowledge of them has led in other fields. As an example of how scientific information of the physical properties of plant pigments played a part in the World War, the detection of camouflaged foliage by aeroplane observers may be mentioned. The Eastman Kodak laboratory staff constructed filters that practically absorbed all light rays except a wide band in the red. Natural green foliage viewed through these filters appeared red, due to the fact that both green and red light is reflected by the chloroplast pigments. Camouflaged foliage on which only green paint was used, appeared green.

In an article by F. M. Schertz on "Commercial Applications of Chlorophyll Derivations" in Industrial and Engineering Chemistry, October, 1927, a list of the importations of chlorophyll extract are given from 1910 to 1924. In this latter year, 3,200 pounds of chlorophyll extract, valued at $5,799 was imported into the United States. This chlorophyll of commerce

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OUR CONTRIBUTORS

Professor E. D. Smith, who writes on personnel management, received his A. B. degree from Harvard in 1912 and his LL. B. from the Harvard Law School in 1916. During the war he was connected with the Council of National Defense later becoming Director of Research for the U. S. Tariff Commission. After the war he gave several lecure courses at Harvard while working for the Dennison Co. In 1928 he received an honorary M. A. degree from Yale and was appointed Professor of Industrial Engineering in the Sheff Scientific School.

Benjamin W. Bacon, the author of the article on excavations at Gerasa, was until the time of his retirement in 1928 a member of the faculty of the Divinity School. Dr. Bacon is a member of the class of 1881, and he received his M. A. in 1892. Breslau University honored him with the degree of Theology. Yale has presented him with the degrees of Litt. D., D.D., LL. D. He has been acting Pastor of the University Church, and is Professor Emeritus. He has done active work in the excavations beyond the Jordan.

Carl G. Deuber, who writes on the pigments found in green leaves, is a member of the faculty of the Botany Department. He received his B. S. from the University of Missouri, and he has studied at Kansas State Agricultural College, Missouri Botanical Gardens, and Washington University. Dr. Deuber received his Ph.D. from the University of Missouri in 1925. Before coming to Yale he was connected with the United States Biological Survey.

Alan M. Bateman, whose article on Geophysical methods in mineral prospecting appears in this issue, is a Canadian by birth. Dr. Bateman received his Ph.D. in 1913. He is Professor of Economic Geology. He has been both Associate and Assistant Professor in the Geology Department. Dr. Bateman is Chairman of the Advisory Board of the Yale Scientific Magazine, the capacity in which he has served since its founding.

Charles F. Scott is the Chairman of the Electrical Engineering Department and Professor of Electrical Engineering. He writes on "Some Aspects of Engineering Education". Professor Scott received his B.A. from Ohio State University in 1885, and he has been awarded honorary degrees by Pittsburg, Stevens, and Yale. Before coming to Yale he was Consulting Engineer with Westinghouse. He has been a member of the Executive Committee of the American Engineering Council since 1921 and is a past president of the A. I. E. E.

Francis T. McNamara, who writes of the new method of visual education used by the Electrical Engineering Department, is a member of the faculty of that department. He graduated from Yale in the class of 1921 S., and during the following year he did graduate work here. Mr. McNamara was employed as test engineer with Western Electric, returning to Yale as Instructor and now Assistant Professor in Electrical Engineering. During the war he saw active service and was Second Lieutenant in 1918.

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Electrical Design Versus Human Fallibility

Automatic Operation is Finding an Important Place in the Field of Engineering Design —The Most Skilled Operative is Liable to Make a Costly Mistake.

By C. R. Beardsley,
Chairman, Accident Prevention Committee, N. E. L. A.*

A FASCINATING element has entered the field of engineering design within the last few years, particularly affecting the layout of electrical switchgear. As in many similar developments, opinion is sharply divided on the change in technique involved. The course to be determined is:—shall we depend, as in the past, on the highly developed skill of operators to secure correct sequence of switching moves, or shall we design equipment with provisions automatically to insure correctness of operation? Continuity of operation, minimum necessity of reserve capacity installed, and of greatest importance in the judgment of the most advanced managers, safety to personnel, are the objectives. It is the purpose of this article to discuss reasons for change of technique and to indicate some of the successful developments.

Growth of Automatic Operation in American Design.

It may be stated without bias that American engineering has been responsible for this newer technique. Equipment of continental design, both as represented in European installations and as exported to South America, include little if any provision to relieve the operator from the full weight of responsibility for correctness of each move made. On the contrary, station after station of American design is being recorded as provided with full automatic operation, or with partially automatic equipment having protective working grounding switches combined with interlocking to compel correct sequence, or with remote control of all moves which might cause outage and accident to personnel. This mounting investment is reasonably reassuring proof that the earlier protective designs have proved dependable and effective in operation.

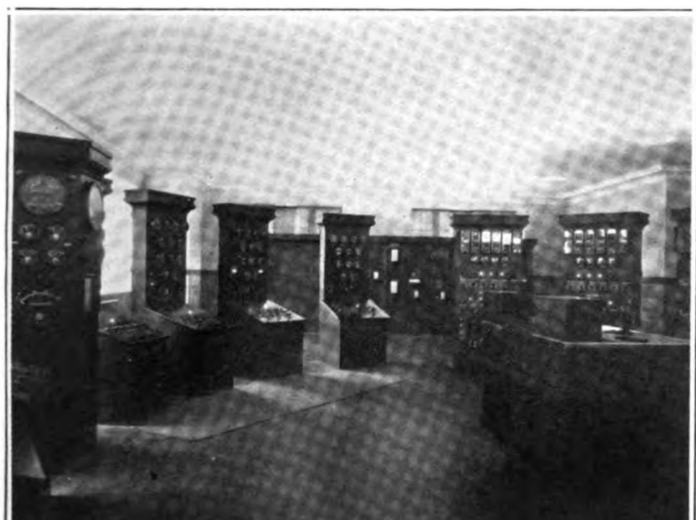

Fig. 1. *High Tension Control Room. Operator's desk centered in oval. Feeder control panels at right of photograph. Generator control panels at left. Master control and synchronizing panel at extreme left. Totalizing panels at rear.*

Decrease in Number of Accidents and Costs Effected.

It is much to be regretted that comparative figures on outages and accident losses classified as to this difference of design have not been published. Such meagre figures as are available indicate a very definite advantage in favor of the more automatic operation. Accident lists are replete with cases of highly skilled operatives who, in a moment of inadvertence, pulled the wrong disconnect, or grounded the live jaws, or even after making the correct moves to "kill" and ground a piece of apparatus, then proceeded to work on the wrong equipment which was still "alive." The infrequent accidents on automatically protected equipment are generally found to be due to inadequate coverage rather than to incorrectness of principle.

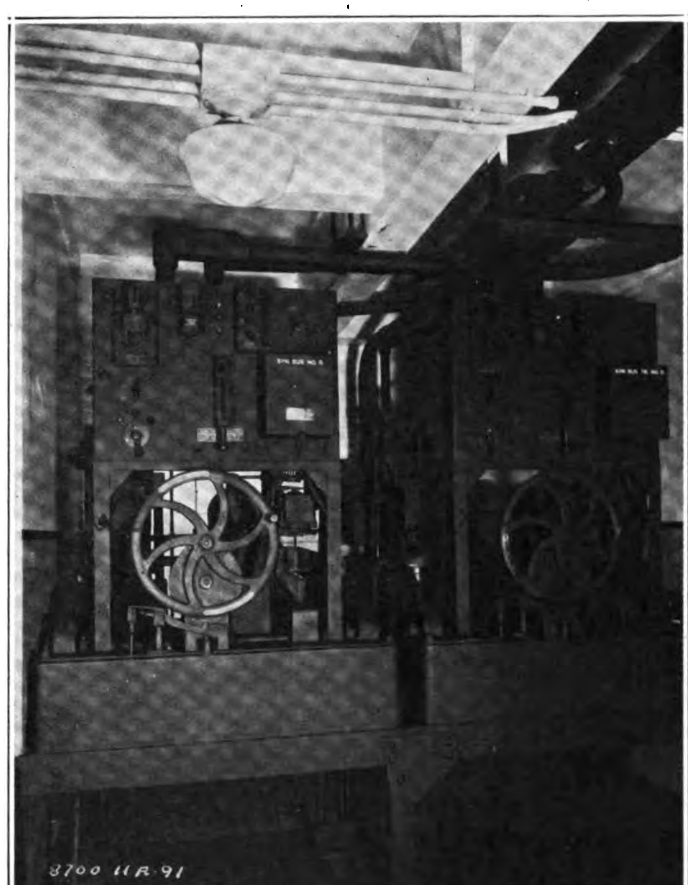

Fig. 2. *Operating mechanisms of main oil circuit breakers vertically phase separated type. Location-mechanism floor of switch house, distant from control panels (Fig. 1). Interlocks affect operation of this mechanism.*

That this movement of automatic sequence is of American flavor, may be related to a considerable extent to quantity production of electrical energy, to the constant effort to multiply

* National Electric Light Association

human effort by mechanical aids, both developed much farther in America than in Europe. The great success of this mechanical substitution for human energy in the material manufacturing field can logically be expected to have its counterpart in methods of electrical production. Curiously the initial impetus seems more closely linked to safety precaution than to the reduction of labor expense. It was soon realized, however, that these objectives are attainable by common means. Thus by reducing the number of manually applied efforts or contacts with equipment, the manpower cost and at the same time the exposure to accident are reduced. When we control the operation by a small switch placed remotely from the point of danger, we reduce at once the human effort required and the exposure to hazard.

A further linkage of interest exists in that whatever tends to safeguard against human accident, at the same time reduces the probability of extensive damage to property sometimes causing outages of long duration. The greater reliability of operation, the less the amount of standby equipment investment required. Thus, what might at first appear to be a questionable increase in investment may prove to be a design productive of very satisfactory returns. An instance of human error may be cited in which a wrong move easily preventable by present protective equipment, caused the outage of several days of a six million dollar turbine unit and electrical repair and accident costs of nearly $30,000. There have been many similar occasions.

The Psychology of the Operative Must Be Considered.

From the design standpoint, fascination exists in the newly infused element of human behavior. Formerly, only the predictable behavior of the apparatus required consideration. Now, the designer must become much more familiar (it must be admitted), than he has been with operating method and especially with the relative importance, location, and extent of hazards. Behind this are the uncertain reactions and fallibility of the human beings who will control the vast bulk and increasing complication of electrical equipment. The designer must study to a considerable extent the psychology of the operative, his behavior under varying conditions and stimuli. Only last week a switchboard attendant in a new station (during an inspection trip) was overheard to remark with much disgust, "They're going to put in another horn! How in hell can I keep the different sounds straight in my head?" This may be a case for more attendants, or it may require more automatic operation with less responsibility thrown back to the attendant by signal. Only careful analysis can determine the best course.

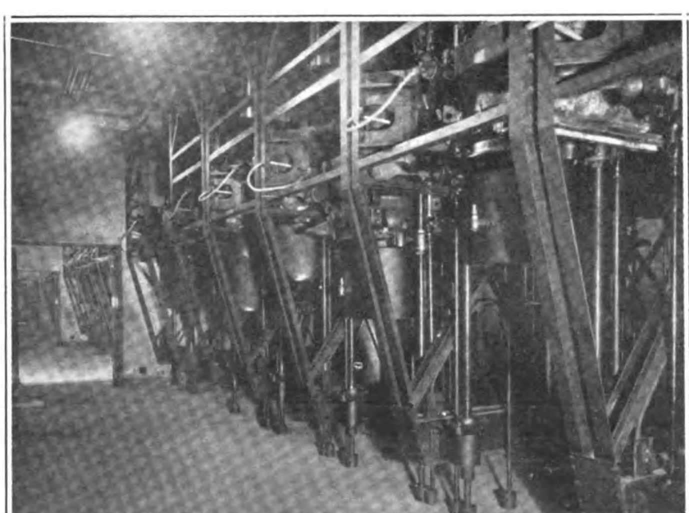

FIG. 3. *Oil circuit breaker units comprising one phase of a four-feeder bus section with selectors. Elevation of switch tanks to connect to bus position is effected by jack screws, three phases being operated at once by mechanism shown in Fig. 2. Elevation and operation of breaker is interlocked with ground switch.*

Accident Prevention in the electrical utilities took definite impetus in the formation in 1914 of the N. E. L. A. Accident Prevention Committee. It was rightly decided at that time that the initial attack must be through education of the individual employee in correct, safe methods of work, and the development of necessary protective tools and methods. Effective work was done and a constantly improving record has been achieved. However, there is still a great necessity for continuing this training of employees. Only recently a large group of employees of one company has been put through the process of rotative appointment to Safety Committees. It has been found that those who have served their terms of one full day per week for four weeks have been thereafter virtually free from lost time accidents, while those who have not served have been responsible for 90% of the frequency and severity rating. It would appear that "Safety Consciousness" is not a meaningless term. Turnover of force must be compensated by continuous educational effort applied.

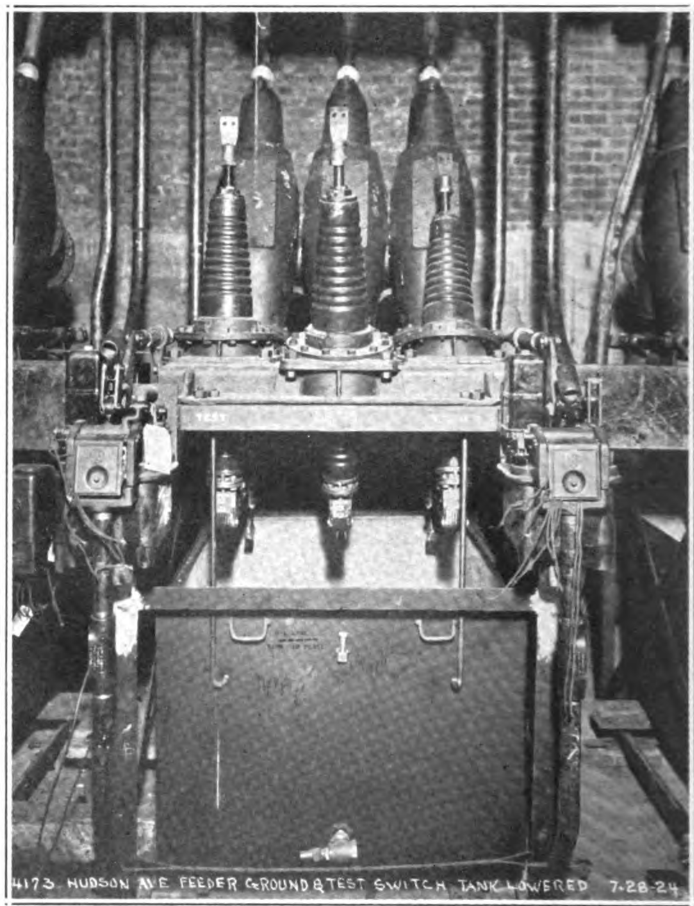

FIG. 4. *Ground and test switch. Tank lowered, showing phase contacts. Operating relays, solenoids, and linkages, left and right, are mechanically interlocked at rear.*

This article, however, has more bearing on that type of employee in whom longer term of service, great skill and knowledge of system and equipment is required. The results of his

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Some Aspects of Engineering Education

The Vital Importance of Science and Technology in Our Modern Life. Types of Technical Education in Europe and America.

BY PROFESSOR CHARLES F. SCOTT

IN the panorama of modern civilization entitled "Whither Mankind" the editor, Charles A. Beard, writes an introduction to a dozen stimulating articles by various leaders of thought in this country and abroad. An eminent professor in a sister university remarked that he got more "kick" out of this book than any other that he had recently encountered.

In the introduction it is pointed out that civilizations fall into three general types—

"Agricultural—slave, feudal, peasant, or freehold
Pre-machine urban—handicraft, mercantile, and political capitals.
Mechanical and scientific."

The first two presumably cover thousands or tens of thousands of years. The latter is comprised of the last two centuries with outstanding progress within the last generation. Western or modern civilization by way of contrast is one that rests upon machinery and science. "It is in reality a technological civilization . . . It rests fundamentally on power driven machinery which transcends the physical limits of its human director, multiplying indefinitely the capacity for the production of goods. Science in all its branches—physics, chemistry, biology, and psychology—is the servant and upholder of this system . . . The pre-machine civilizations retain their essential characteristics through long lapses of time. But machine civilization based on technology, science, invention, and expanding markets must of necessity change—and rapidly. The order of steam is hardly established before electricity invades it; electricity hardly gains a fair start before the internal combustion engine overtakes it. There has never been anywhere in the world any order comparable with it, and all analogies drawn from the middle ages, classical antiquity, and the Orient are utterly inapplicable to its potentialities, offering no revelations as to its future."

Scientific and Technical Training Essential

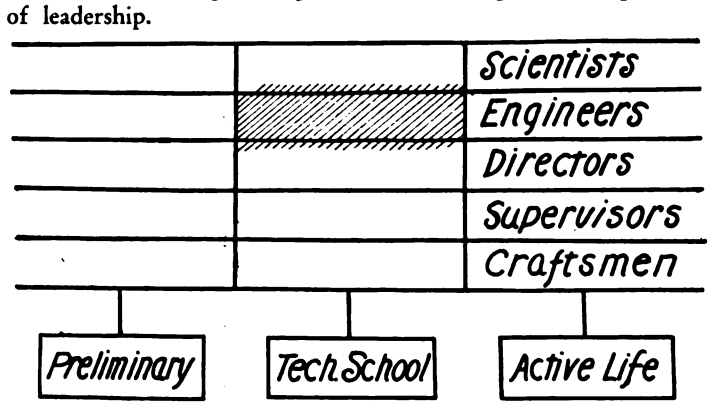
What, then, is necessary to carry on this new dynamic civilization, to prevent its decline, to promote its development, to realize its opportunities, to meet its problems?

These problems are of two kinds. One is material, non-personal; it has to do with things, with the scientific and mechanical elements on which the new civilization is based. The other is the problem of human adjustment to the new conditions.

For the proper development of the technical and mechanical side of our modern life we must look to a new kind of training and education, one which was unknown in the older day. In the minds of most people this type of education is found in the engineering courses in our colleges. These are of comparatively recent growth. Of our present engineering schools Rensselaer, which dates back a little over a century, is the oldest. But it was not until about eighty years ago that it changed from an elementary school of general science to one of concentrated engineering. About the same time the Sheffield Scientific School and a few others had their beginnings. In 1860 there were four schools in the country which would now be classed as engineering. A decade later there were four times as many, and in 1880 there were 85; now there are about 150 giving engineering degrees.

Engineering Schools and American Industry

The rapid rise of the engineering schools was coincident with the expanding industrial development of America following the Civil War. There is a close interrelation between the development of the engineering school and the expansion of American industry. The injection of science and scientific methods into industry during the past twenty-five years is largely due to the graduates of the engineering school who have grown into positions of leadership.



Horizontal: Types of Training Needed. Vertical: Stages in Training of the Individual. Large emphasis is now placed on the Engineering College.

The Field of Technical Education.

For a time industry did not know how to use the engineering graduate. Sometimes he was assumed to be a full fledged engineer or technical expert ready to do productive work of a high order and was blamed for not possessing a practical attitude and judgment which experience alone can produce. Many industries neither expect nor desire the graduate who is narrowly trained as a specialist. They call for a broad and fundamental training and regard it as the duty of the industry itself to provide the specific training in a period of postgraduate experience.

Recognizing the changing conditions, the schools through the Society for the Promotion of Engineering Education undertook several years ago a general survey of the situation in engineering education. This survey covered the work now being done by the schools of the country with a general inquiry into the characteristics and preliminary preparation of the freshman and the positions held by engineering graduates. In general it was found that the work of the schools is of a solid and substantial character. There is very little that is of the shoddy sort and the present curricula do not need a radical change. Improvements are to be looked for primarily in the quality of students and of teachers.

Technical Education Broadly Considered

It is important to take a more general survey of the whole field of technical education. We have concentrated attention upon the four year engineering course as representing the whole of technical and professional education. If there is criticism that the graduates are not sufficiently technical or that they are not familiar with economics and business or that they are not fluent writers or speakers, the usually proposed remedy is the introduction of some new subject into the overcrowded four year course.

Are we right in placing almost exclusive emphasis on the four year course and expecting it to produce whatever kind of finished product is wanted? No. The four year engineering course is a type of education combining non-technical, scientific and engineering subjects in a coordinated whole. It is a fitting training for professional engineers and for men of affairs. A year after graduation only ten per cent of engineering graduates have duties which are primarily administrative, but after twenty years it is over seventy per cent. In fact, engineering schools are supplying men for handling the personnel or human prolems of modern life as well as its material and mechanical affairs. Industrial problems and management are finding a place in the curriculum.

In the investigation of engineering education to which reference has been made, the field was extended to include European countries and the Director, Dr. W. E. Wickenden, has made several trips abroad. The emphasis on other phases of technical education abroad led to a comprehensive consideration of the whole field of technical education which Mr. Wickenden has illustrated in the accompanying diagram. The three vertical sections show how the elementary school, the technical or engineering school and the subsequent study and experience—all are essential parts of the training of the individual. The horizontal sections represent the different types of technical work required by industry. There are the scientists specially equipped by their technical training as specialists in the handling of research problems. Next comes the engineering group not narrowly confined but overlapping somwhat into the scientific field on one side and the next band which includes the directors of technical operations in industry. Below this come supervisors and then craftsmen. Quite a large volume of technical work in industry falls in these last divisions for which a different sort of training than that given by the engineering school is adequate. In other countries large emphasis is laid upon education for these other grades. In England, for example, the technical institutes giving two or three years of technical training supply more men to the industries than do the institutions of university rank. In this country on the contrary these schools supply but few men as compared with the engineering schools. There are a score of such schools, but there is no definite type, they differ greatly among themselves, they do not have the rank and status which their importance deserves. They are privately endowed or municipally supported; they have day courses or night courses; they give general studies or specialized training. The New Haven College (Y. M. C. A.) conducting night classes in buildings of the Sheffeld Scientific School is doing work of this kind. A national survey of these schools is now being conducted under direction of Mr. Wickenden by Mr. R. H. Spahr.

Technical Education at Home and Abroad.

Mr. Wickenden recently summarized the general situation in technical education on his return from his investigations abroad in a concise but illuminating article in "Power," February 19th. He states that Great Britain lost fifty years of her early lead over Germany through ineffectual development in technical education. She depended upon the incidental scientific instruction of working men and did not realize that a specially trained personnel was needed to apply science to industry effectively.

France created a variety of schools and held undisputed leadership up to 1850; then followed forty years of arrested development under a State leadership without effective initiative during which early supremacy was irretrievably lost. In Germany technical education was opposed by conservative educators but was fostered by far-seeing statesmen who transformed a group of backward agricultural states into a powerful industrial empire. New types of schools were created and there was a coordinated central committee representing the profession, the industries, the schools, and the Government ministries.

Mr. Wickenden then concludes his statement with these paragraphs.

In the United States our pioneer efforts "to apply science to the common purposes of life," quickly solidified into the one special form of professional discipline for engineers. As a result of this early fixation one aspect of technical education alone has eclipsed all others; schools have been multiplied on the one pattern of the degree-granting college; the training of craftsmen, foremen and supervisors of industrial production has either been neglected or has been thrown back on industry itself; an undue premium has been put on going to college; the effort to make one sort of school cover too wide a range has led to indefiniteness of aims and compromise in standards; inadequate provision has been made for a large section of our youth; and industry has been given an unbalanced recruitment. We have done parts of the task well, but no one has seen the task whole.

It is plain that we cannot look to a central government to create and sustain a well-balanced policy and program of development. Industry cannot do it alone. The engineering profession is not yet awake to the problem. Our educators and schools are wrapped up in their own local and special interests. The Society for the Promotion of Engineering Education is not an adequate agency as it stands, but it is the best nucleus we have to start with. If it could take the initiative in bringing the now scattered interests together in conference and promotion and sustain it for ten years, we might prepare the way for some central representative agency, such as that in Germany, and awaken the public to the vital part that an adequate and well-proportioned scheme of technical education has in industrial prosperity and development.

Resume—Engineering at Yale.

Scientific, engineering and technical education are essential in our new mechanical and scientific civilization. They are fundamental to its success; not only for the proper development of the material side but for an understanding adjustment of the human relations which enter into industry in its larger sense and also into the new problems which enter into each branch of our modern life. Mr. Hoover, when he became President of the American Engineering Council eight years ago last November, stated that many of the difficult problems which confront modern life have been brought about through the achievements of the engineer and can best be investigated and handled by him although they may be primarily concerned with human relations. He proposed an investigation as to the

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The Mine Inspection Trip of 1928

Three Seniors and Two Professors Take Four Weeks Trip Through Canadian Ore Deposits as Part of the Course of Mining Engineering.

BY C. P. KNAEBEL, '29S.

AMONG the undergraduate courses listed in the University catalogues is *Mining 22s*, "Mine Inspection Trip and Mine Surveying. Although this course does not have the drawing power of such ones as *Industrial Physiology* and *Tennyson and Browning*, in point of interest and educational value it deserves an equal rank with them, and in some respects, it transcends them. It successfully combines education with a very pleasant vacation.

The trip of last summer extended from the first of September to the opening of the Fall term. A large measure of the success of the trip was due to the means of transportation generously provided by Professor Behre, namely, his seven-passenger Packard touring car. Starting out from his summer lodging in New Hampshire, Mr. Behre drove by way of Burlington and ferried across Lake Champlaine to Ogdensburg, New York. The other members of the party joined him along this route, and at the last named point the personnel of the trip was completed.

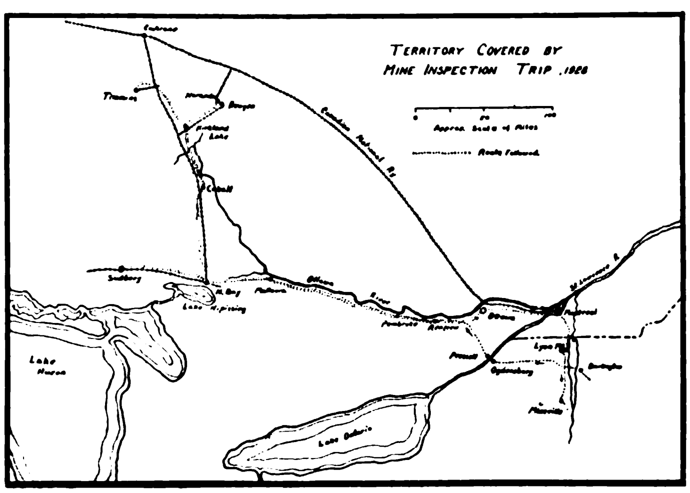


FIG. 1. *Territory covered by inspection trip.*

The contents of the automobile were arranged comfortably and scientifically, as behooved a party of engineers. On the front seat rode the faculty, Professor Behre at the wheel and Professor Warner with the road maps. In the tonneau was most of the baggage, carefully arranged, and on top of it the Senior Class in Mining Engineering, viz. Messrs Davoll, Riotte, and Knaebel. Everyone was very comfortable, but there was no possible menace of cargo shifting.

Leaving Ogdensburg, we ferried across the St. Lawrence to Prescott, where the customs examination was quickly passed, and headed north and west with Sudbury as our first main objective. The country passed through was uninterestingly flat until we reached the valley of the Ottawa at Arnprior. Then the route followed this picturesque and wild valley as far as Mattawa, where we spent our first night in Canada, having made the run at an average rate of something greater than the Ontario speed limit. On the next day we reached Sudbury and became established at the King Edward Hotel, for which hostelry we have only words of praise. The highway from Pembroke to North Bay is of recent completion, and of good quality. It passes through a wild and forested area of negligible population, and on it we saw less than ten cars in over one hundred miles of driving.

FIG. 2. *Smelter of the Chateaugay Ore and Iron Company at Standish, New York.*

At Sudbury the quest for knowledge began in earnest. This is the center of the world's greatest nickel producing region. Several mines and smelters are operated by the International Nickel and Mond Nickel Companies, which have recently combined. Our party went underground in the most famous mine of the region, the Creighton, visited two smelters, and inspected the surface plant of the Frood Mine of the International Nickel Co., only partly completed at that time. All of the mines are in bodies of massive sulfides of copper, nickel, and iron. After more or less preliminary concentrating, these ores are smelted to form copper-nickel *mattes* (artificial sulfides of high metallic content), which are shipped to refineries. The ultimate products are nickel, copper, and the famous *Monel metal*, which is an alloy of the two. Some sulphuric acid is produced also. One of the most interesting features of this "camp" was the Frood mine, above mentioned. Expenditures running into millions are being laid out in a shaft and surface plant to exploit an orebody which up to a few months ago had never been seen. Sample cores from diamond drill holes were accepted by the engineers as conclusive proof of the presence of an orebody large enough to warrant this investment. Behavior of the ore in other mines was, of course, taken into account.

Whatever importance Sudbury may have as a mining camp, as a summer resort, and a place of beauty it is in a class with the Russian Steppes and Bayonne, New Jersey, and we left its wastes, denuded by smelter fumes, without regrets.

To reach the gold and silver camps of central Ontario we retraced our route as far as North Bay, and then turned north-

ward on the new Ferguson Highway through a wild country of many lakes and virgin forests. The region is so bestudded with small lakes that canoes and seaplanes are a common means of travel.

School reopened at Cobalt, close to the town of Haileybury, where we put up at the Haileybury Hotel.

Great Silver Deposits

Silver was discovered in this region when the railroad was driven through in 1903, and since that time it has enjoyed amazing prosperity. In production of silver it ranks fourth in the world, its three peers being located in Mexico. Besides silver, some cobalt, nickel, and arsenic are extracted. In 1911 it reached its climax when 31,500,000 ounces of silver were produced. Although it is still active, production is now on the decline.

The party inspected the mine and mill of the Canadian Mining Corporation, and also the famous Nipissing Mill, once a world beater in silver output. The silver is extracted from the finely ground ore by the cyanide process, in which a soluble salt of silver (or gold) is formed with potassium cyanide, and from which it is later precipitated by replacement by zinc. All of the gold producers later visited use a similar process.

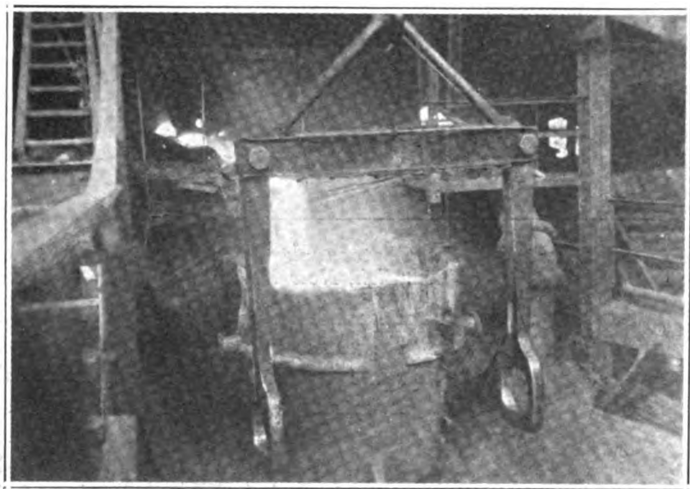


Fig. 3. *Pouring matte at the Mond Nickel Company's smelter near Sudbury, Ontario.*

From Cobalt we resumed our northward course as far as Kirkland Lake, an important gold producing camp since 1910. Hotel accommodations reached a low ebb at this point, but it was too late to turn back, and hopes of obtaining a certain amount of "highgrade" from the mines steeled our powers of endurance. The party went underground in the Teck-Hughs, Lake Shore, and Wright-Hargreaves mines, and went through the mills of the two former. Permission to "highgrade" was liberally granted, and from the Lake Shore we emerged triumphant with fully sixty cents worth of exhibition ore. The gold occurs in veins of snow-white quartz several feet in width, and these are mined by a method known as *shrinkage stoping,* quite commonly used in Ontario, where conditions are favorable, but less so elsewhere. The basic principle is to support the walls of the veins, which are nearly vertical, by leaving most of the ore after it is broken in the place whence it came, removing only enough to maintain an open space between the broken rock and the solid portion above for the miners to work in. Thus mining is advanced upward in a more or less horizontal plane, blasting out the vein material overhead, and leaving it as broken ore underfoot. After part of a vein has been completely broken up in this way, the ore can be drawn off through a tunnel below, and if the walls cave there is no one between them to get pinched.

Second Largest Gold Mine in the World

Another day of travel brought us to Timmins, center of the Porcupine gold region. Opened up in 1910, this has since become one of the greatest of gold fields. The Hollinger Mine, a small part of which we saw in a full day of activity, ranks second only to the Government Areas Mine of South Africa in value of output. In one year, 1926, the value of its pro-

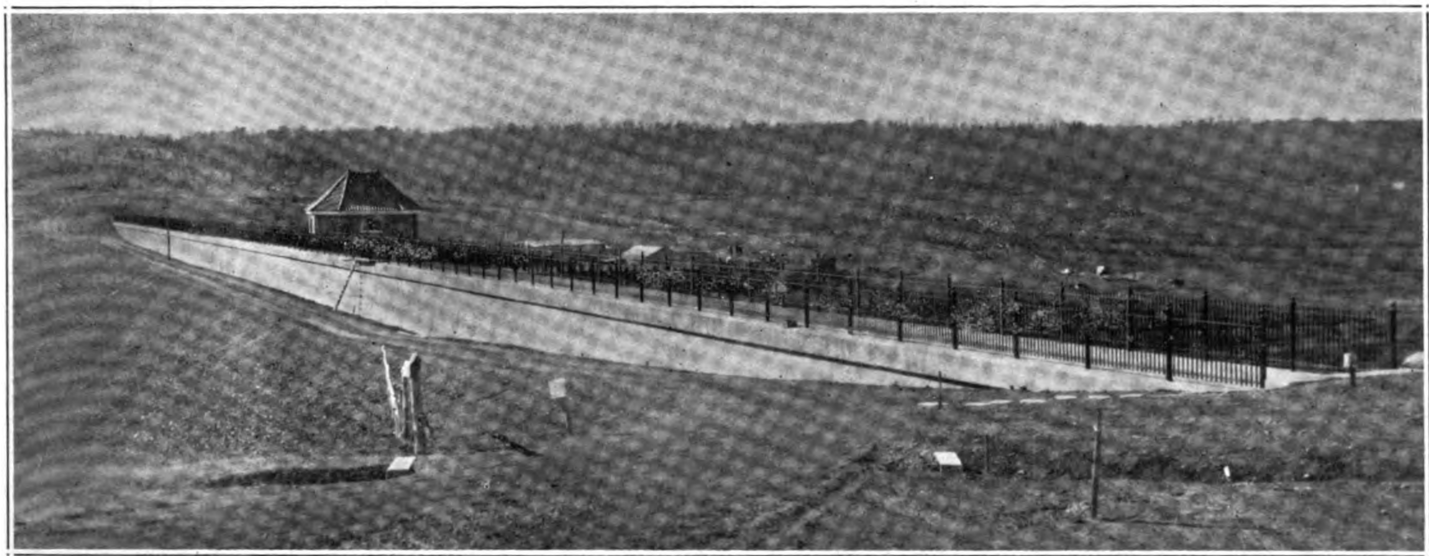
Fig. 4. *Main Street, Rouyen, Quebec. The stack in the background belongs to the smelter.*

duction was $14,800,000. The following day we inspected the McIntyre Mine, being especially interested in its Number Eleven shaft, which was sunk four thousand feet in twenty-five months. at the time of sinking a world's record. One other point of interest was the Coniaurum Mill, which represents the best practice in modern cyanide plant design.

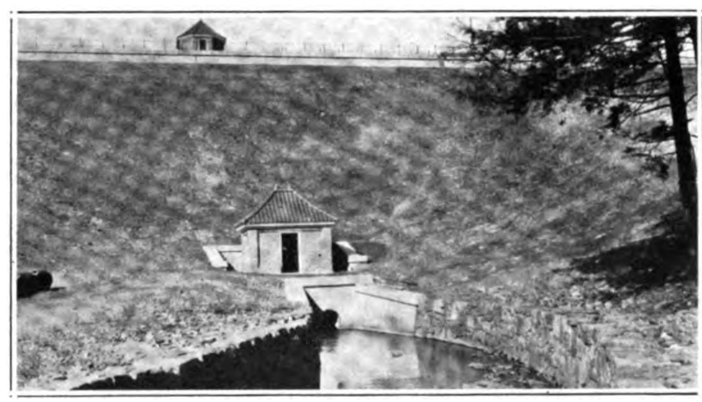
Returning to Kirkland Lake, the party for the first time resorted to train travel, and patronized the recently completed branch of the Nipissing Central Railway to the own of Rouyen, Quebec. This and the adjoining town of Noranda are aged by not more than three years, and they are a strange combination of twentieth century civilization and the frontier. Duco painted sedans of the latest model bounce along streets that are at one place bare outcroppings of jagged rock, and the next hub-deep in mud. The proprietor of our hotel had a "rough and tumble" with a drunken Kanuck at the same time that an engineer was telephoning a report to his employer in Toronto, four hundred miles away. The main reason for this sudden growth is the Horne copper-gold mine at Noranda. This has been on a producing basis for about a year, and will soon be of considerable importance in the copper market. Besides being rich in copper, the ore runs as high as five dollars to the ton in gold. The Horne smelter exemplifies the latest trend in copper smelter design, and is a very efficient plant. It is the pioneer in a region which shows promise of great expansion.

This marked our last professional stop in Canada. We returned by the way we had come to North Bay, and from there continued down the Ottawa Valley to the city of Ottawa, and on to Montreal. There the party spent the night and enjoyed for the last time the excellent Canadian food.

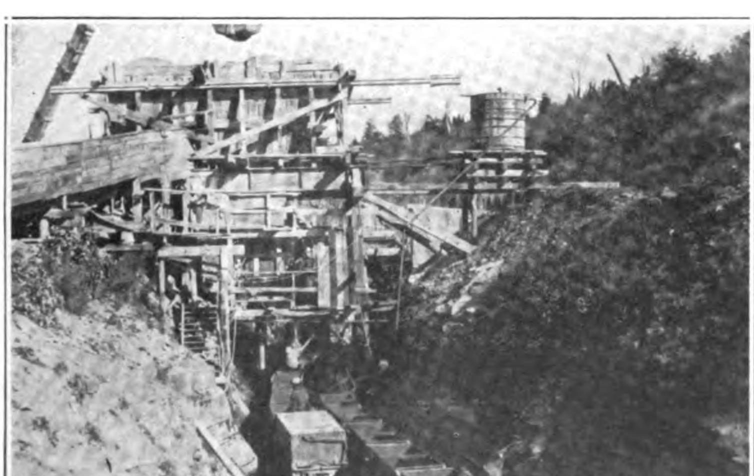
(*Continued on page 47*)

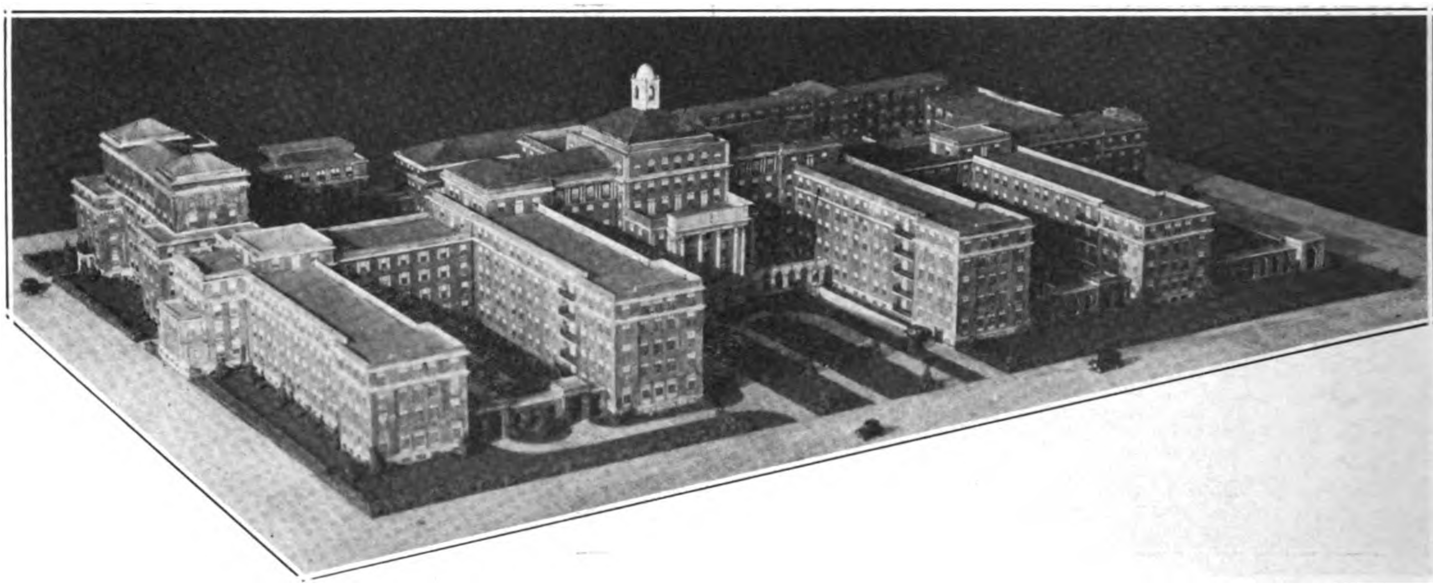


The new reservoir of the New Haven Water Company at North Branford. The Totoket reservoir will hold fifteen billion gallons and will cover about 1,500 acres. The reservoir will be filled by the Gulph Tunnel, 5,000 feet long, and the Sugar Loaf Tunnel, 13,500 feet long.

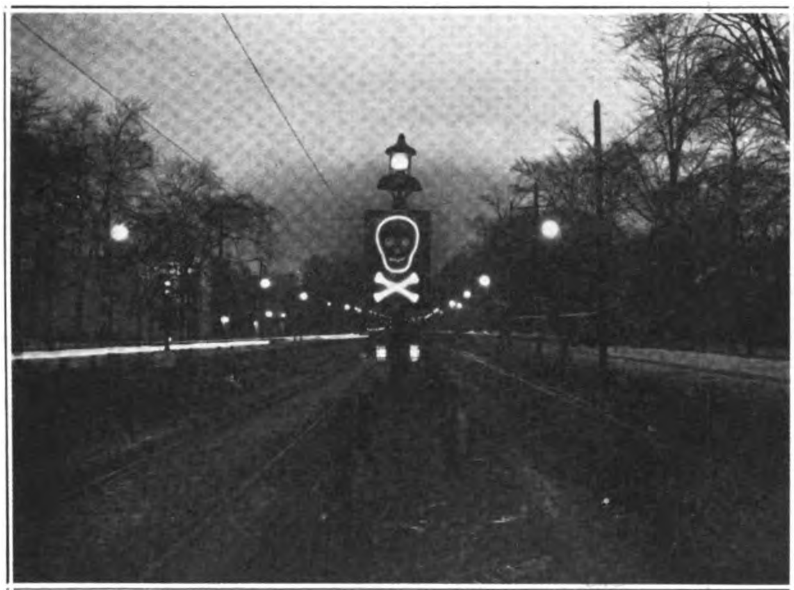


The city mains will be supplied by the 5,000-foot Great Hill Tunnel. The main dam across the Branford River is 1,200 feet long and is over 100 feet high. The main gate house is separate from the dam, standing 210 feet from the shore and controlling the outflow from the reservoir to a depth of 50 feet. (Top) The main dam from the downstream side. (Center left) The gate house of the Great Hill Tunnel. (Center right) Another view of the dam, giving some idea of its height. (Lower left) West portal of the Gulph Tunnel, showing the concrete mixer for the lining. (Lower right) The East portal of the Gulph Tunnel.

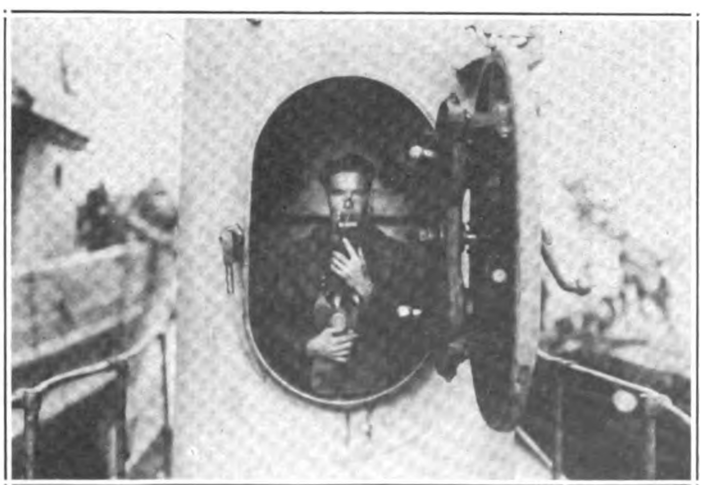




ABOVE. *A picture of the architect's model of the new Hospital Wards and Clinic to be erected at the School of Medicine. These buildings will face on Howard Avenue, and those buildings now facing Sterling Hall of Medicine will form the back of the group. The recent gifts announced by Yale University have made possible these buildings as well as the new Institute of Human Relations. Construction has now been started on this addition to the Medical School facilities.*

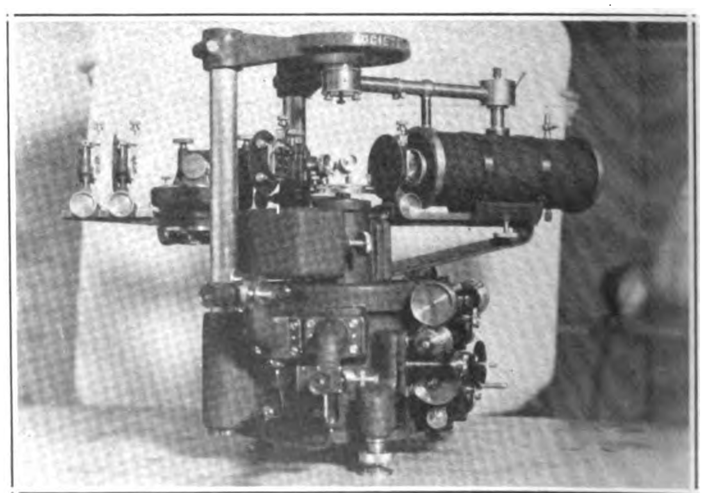


LEFT. *A view showing the novel illuminated signs which have been installed on a boulevard in Detroit to warn motorists. This is but one of the many innovations employed by the Police Department of that city to decrease motor accident casualties and facilitate traffic.*

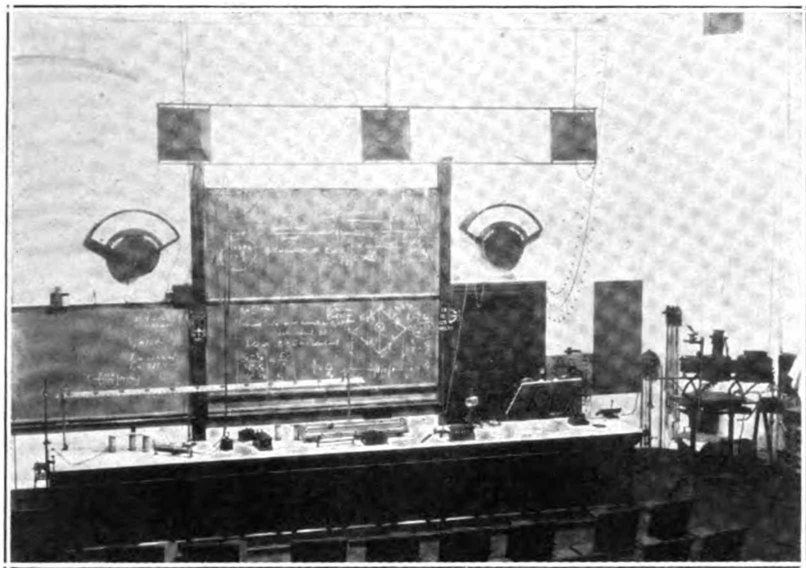


Underwood

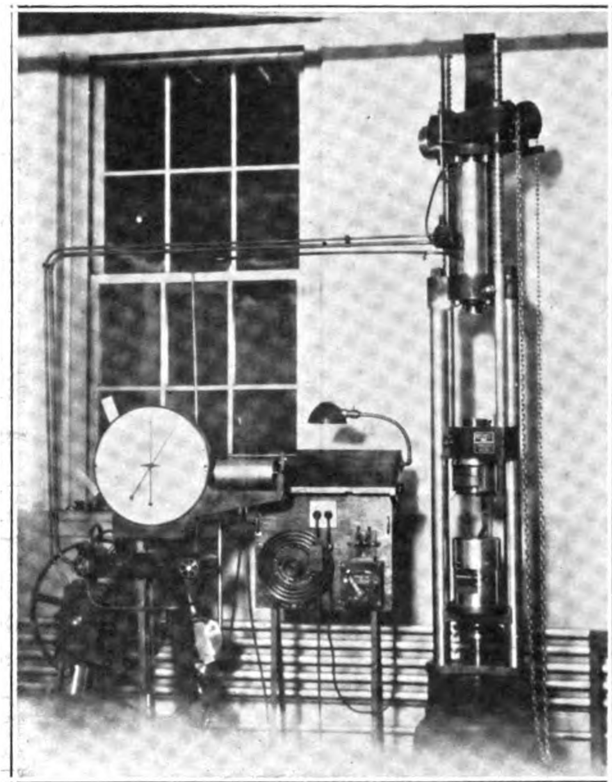
ABOVE. *A close-up of the new "escape-lock" on the submarine S-4, which has been discovered. The sailor is shown wearing the new "lung" or inflated oxygen mask. This picture was taken just before the first test, which was successful.*



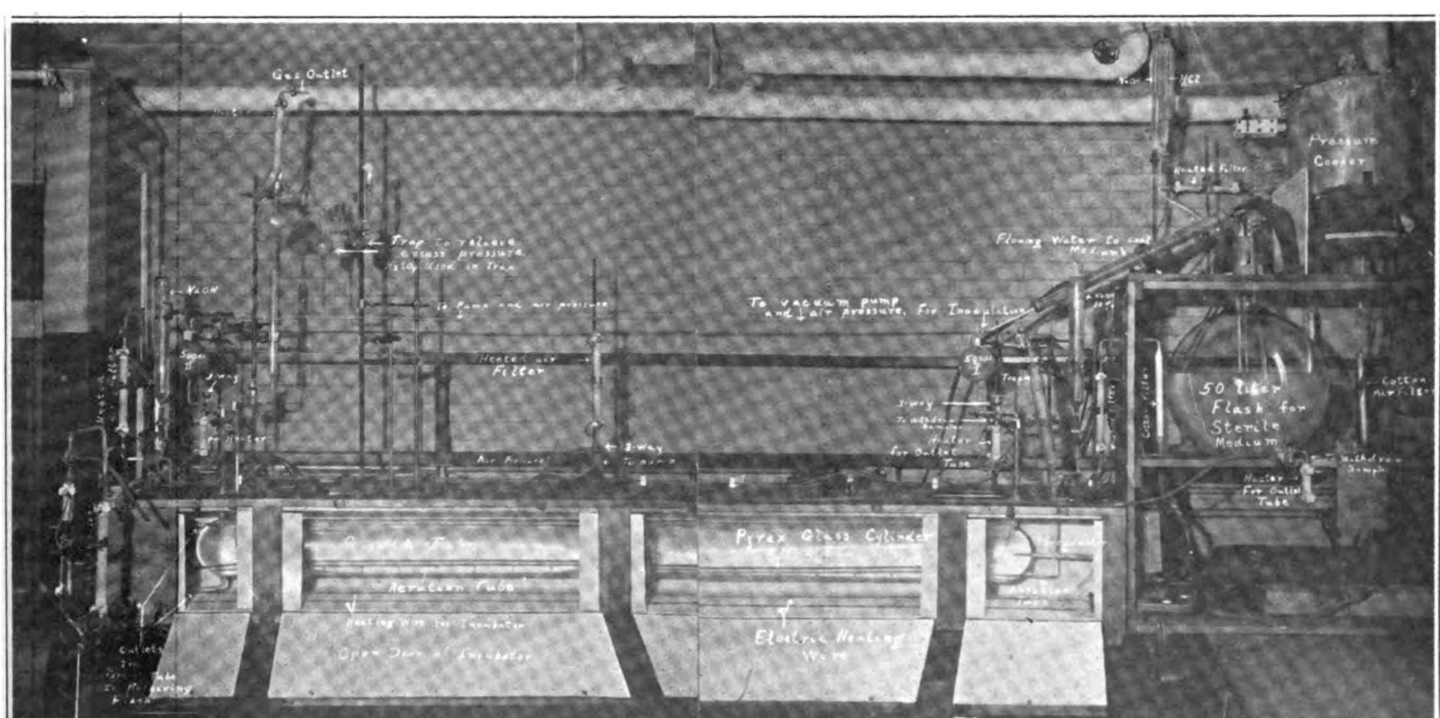
ABOVE. *An X-ray spectrometer recently installed at the Sloane Physics Laboratory. This machine was designed by Prof. R. T. Compton and was built by the Geneva Society. It is used for studying the reflection of X-rays by crystals.*



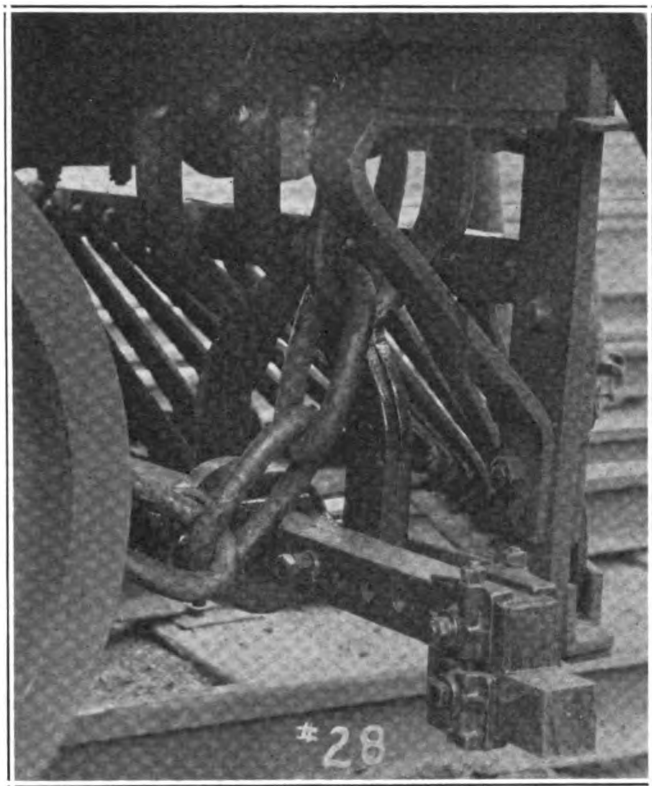
ABOVE. *The lecture room in Sloane Physics Laboratory, with the lecture table set up for Dr. Uhler's lecture on Ohm's Law, which is a part of Physics 16b.*



UPPER RIGHT. *The Ammsler Hydraulic Tension and Compression Tester which is installed in the testing laboratory in Sheffield Laboratory of Engineering Mechanics. The machine has a maximum capacity of 50,000 pounds. It contains an automatic, autographic recording apparatus. The machine was installed in the Laboratory last fall and was imported from Switzerland.*

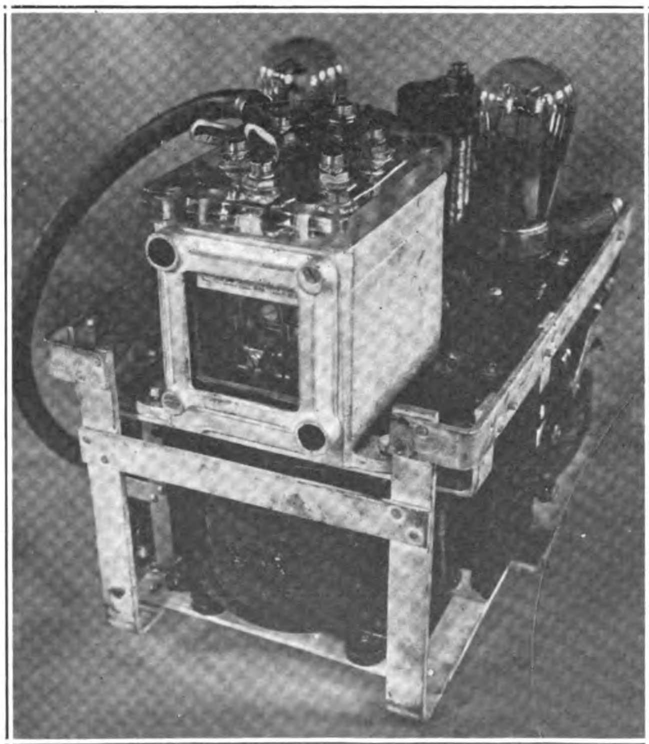


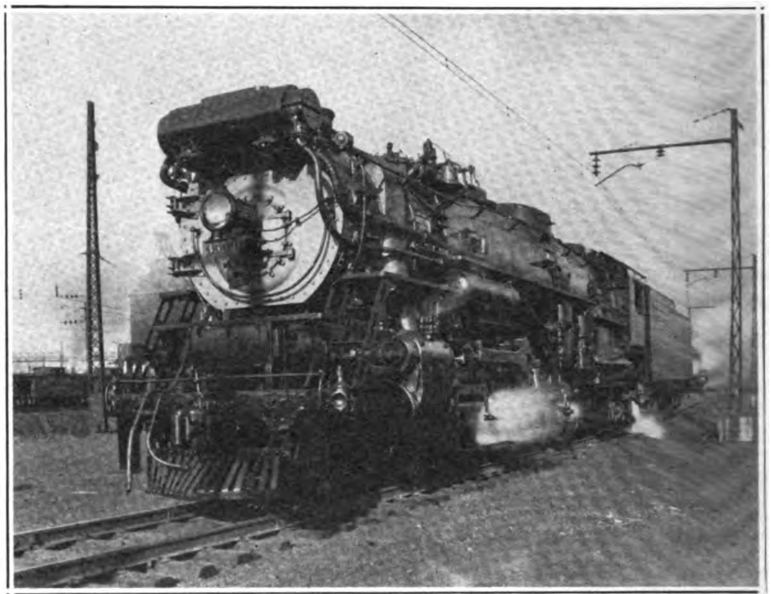
ABOVE. *A new tuberculosis bacteria incubator developed by Dr. Moyer, a research bacteriologist, in the Sterling Chemistry Laboratory. Dr. Moyer is a Fellow of the National Research Council. Certain bacteria were desired in much larger bulk than can be manufactured by the usual methods. The air tight glass incubator, which permits the growth of bacteria easily under laboratory control, enables Dr. Moyer to obtain in one week as many bacteria as could be obtained by the old method in a year. From ten to twelve grams are produced per day. This technique now enables the chemist to study products which were never hitherto approachable in sufficient quantities.*



ABOVE. *This view shows the pick-up coils, under the pilot, which pick up an alternating current of variable frequency sent through the track circuit. The frequency depends on the distance ahead for which the track is clear. This current is amplified and repeated by the master relay (shown below), which passes it to the relay box (at right).*

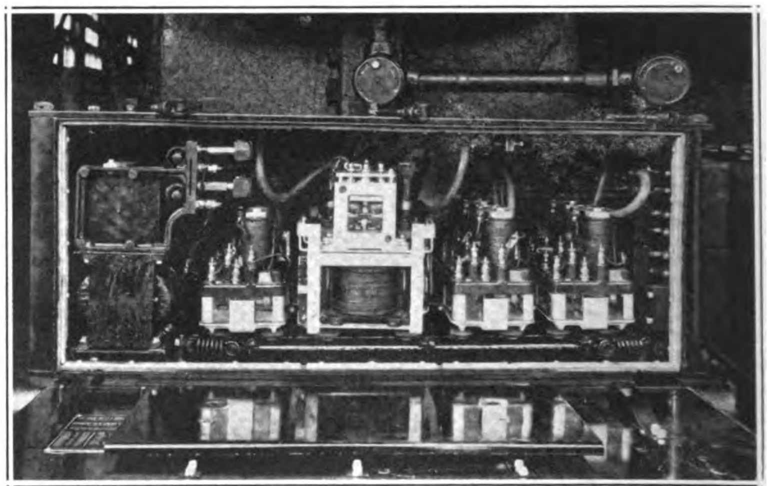
LOWER RIGHT. *The pneumatic relay (upper right hand corner) controls the air brake distributing valve and sets the brakes if necessary. When the brakes have been automatically set they may be released only by operating the manual reset switch located just behind the relay.*

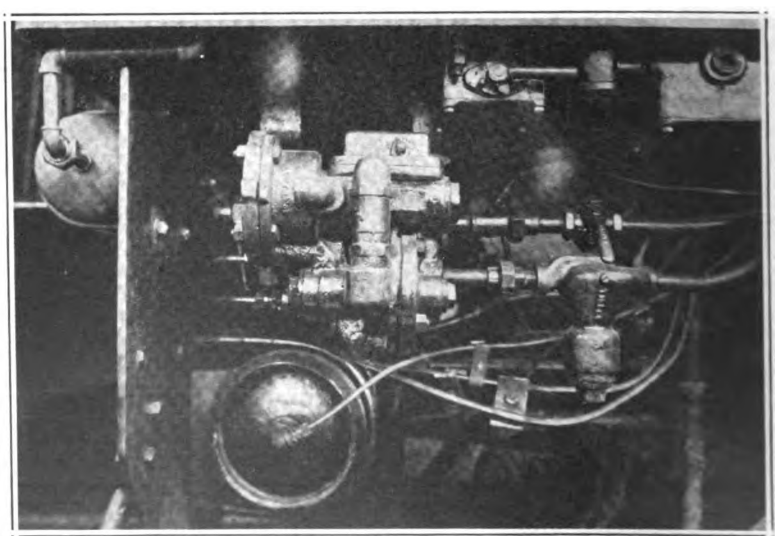




ABOVE. *A high-speed freight engine equipped with the recently installed continuous inductive coder type of automatic train control used on the New York, New Haven and Hartford between New Haven and Providence. The main mechanism box may be seen below and in front of the boiler smoke box.*

BELOW. *The decoding relays here operate light signals in the cab and the "pneumatic relay" under the cab floor. These relays are located in the mechanism box.*



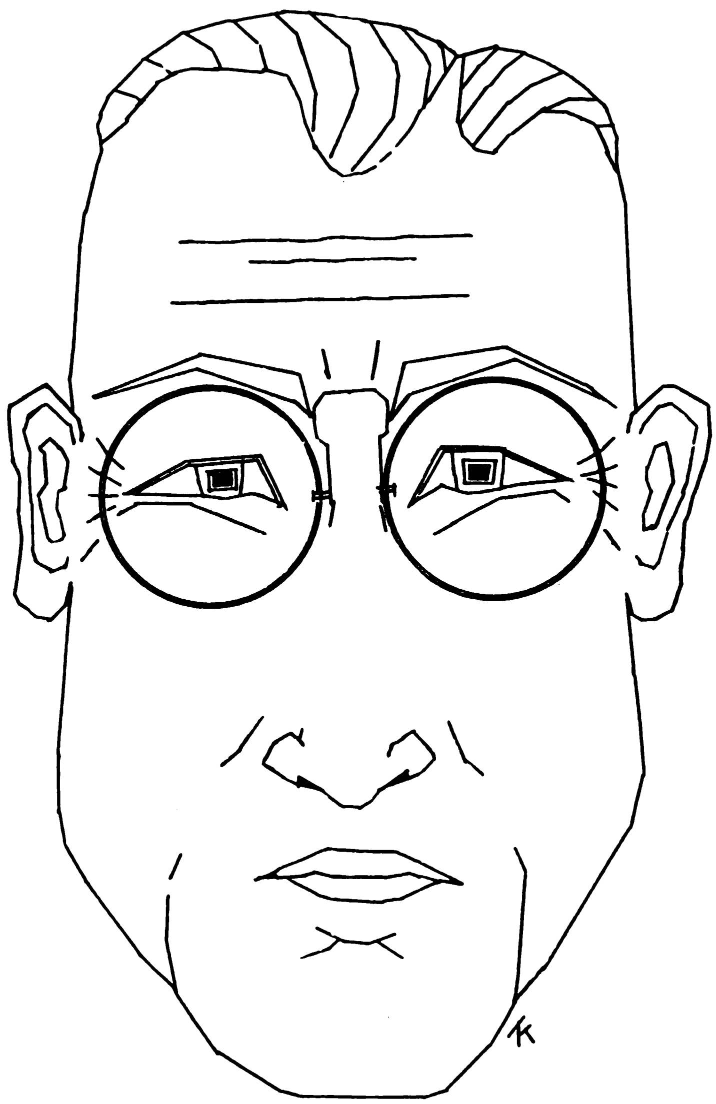


P·E·R·S·O·N·A·L·I·T·I·E·S

ALAN MARA BATEMAN

PROFESSOR BATEMAN has dwelt in that hive of geological activity, Kirtland Hall, for the last fifteen years or more. Kirtland Hall, on the first floor of which you may, if you are lucky, find Ford and his minerals; on whose second floor find Knopf surrounded by rocks and Flint buried in maps. If you persist to the third floor you will find Longwell hidden behind books and at last Bateman in a cloud of pipe smoke engulfed in proof sheets, secretaries, graduate students, and ore specimens!

Bateman is a Canadian by birth. He very early became interested in things geological, for we find him doing field and mine geological work several years before he took the B.S. degree at Queen's University in 1910. He then came to Yale to do graduate work in Economic Geology under the late Professor John D. Irving. Meanwhile he maintained his connection with the Canadian Geological Survey as an assistant geologist. He took his doctor's degree at Yale in 1913. The next two years were spent as a member of a group of geologists who were engaged in the investigation of the secondary enrichment of ore deposits, especially those containing copper. This important project was financed by several of the large copper producing companies of the country and was one of the earlier cases where capitalists recognized the value to them of pure scientific research. This investigation took Bateman all over the United States and gave him a wide first-hand knowledge of copper ore deposits. One result of this experience was his appointment later as consulting geologist for the Kennecott Copper Co., an important position which he still holds.



He returned to Yale in 1915 as an instructor in geology, and a year later was made an assistant professor. After Professor Irving's death in France he took charge of the department of Economic Geology and has remained its head ever since. He was advanced to the rank of Associate Professor in 1922 and to Professor of Economic Geology in 1925. He has always carried a heavy teaching schedule. It has usually included one or more divisions of the course in Elementary Geology in addition to his special courses in Economic Geology and the personal direction of a large number of graduate students. Frequent scientific papers have come from his laboratory, written either by himself or by students who have worked under his direction.

The unusual thing about the man is the variety and scope of his activities. Probably his most important and far-reaching work has been as an editor. *The Journal of Economic Geology* was established in 1905, and Professor John D. Irving, then newly come to Yale, was its first editor. It was started in order to give that rapidly growing and important branch of geology its own particular organ. Shortly after Bateman came to Yale as an instructor he became an associate editor of this journal, and after Irving's death was made editor-in-chief and has occupied that position ever since. He has proven very successful as an editor. Economic Geology occupies an important and honorable position among the geological journals of the world, and much of this is due to the editorial ability and energy of Bateman. A department devoted to discussion and argument, which he inaugurated, has proved a very lively and stimulating influence in the world of economic geology.

This journal is not the only one which owes a debt to Bateman. A few years ago, when Professor E. S. Dana, the veteran editor of the *American Journal of Science*, became suddenly ill, it was Bateman who was called upon in the emergency to take charge. For two years or so he ran two journals, apparently with as great ease as he had conducted one. Later Dr. Ernest Howe relieved Bateman of that responsibility. And in this catalogue of editorial activities we must not forget that he has been much concerned with THE YALE SCIENTIFIC MAGAZINE. He was a member of the faculty advisory committee who helped the first editorial board to formulate their plans and has served ever since as its faculty advisor. Its success is largely due to his enthusiasm and constant assistance.

When you have an occasion to call upon Professor Bateman in his office, don't be dismayed by the sign on his door that invites you to knock elsewhere. Be bold and disregard the admonition, and when a cheery voice says "come in," obey the summons. Then if you have need of advice in things geological, scholastic, financial, or what-not, you will get not only sympathy but what is really worth more, expert advice from a friendly soul.

Modern Method of Visual Instruction

Application of Daylight Screen and Short Focus Lens to the Projection of Lantern Slides in the Classroom.

By F. T. McNamara

THE object of this paper is to present certain modern methods of education which have been found to be extremely effective. Whenever one is dealing with objective realities it is desirable to give the student the benefit of direct observation of these. But it is not always possible to do so. A geologist can scarcely take his class to the Grand Canon to study its formation nor can an historian bring the field of Gettysburg to his class-room. It is desirable, however, to have some sort of a visual representation of these objects before the class to supplement and make more effective the word-picture and blackboard drawings of the instructor. This is especially true where the phenomena under study are complex and require a sense of proportion of the details involved, as, for instance, in the study of types of architecture, statistical information or complicated circuit diagrams. It is to such material that the methods discussed find ready application.

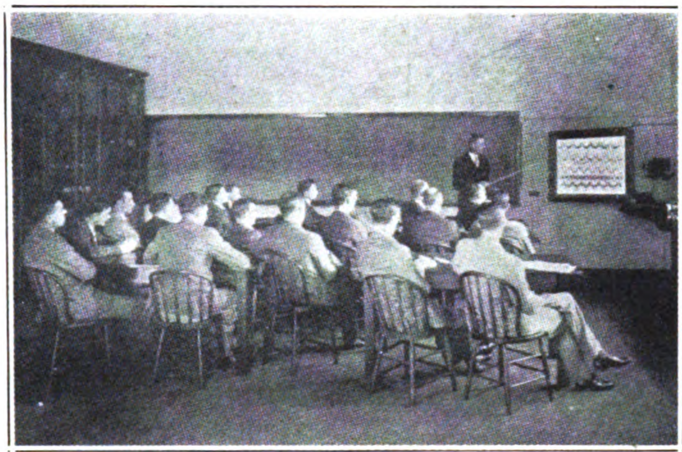


FIG. 1. *An illustration of the daylight screen system used to demonstrate complex phenomena in a class in communication engineering.*

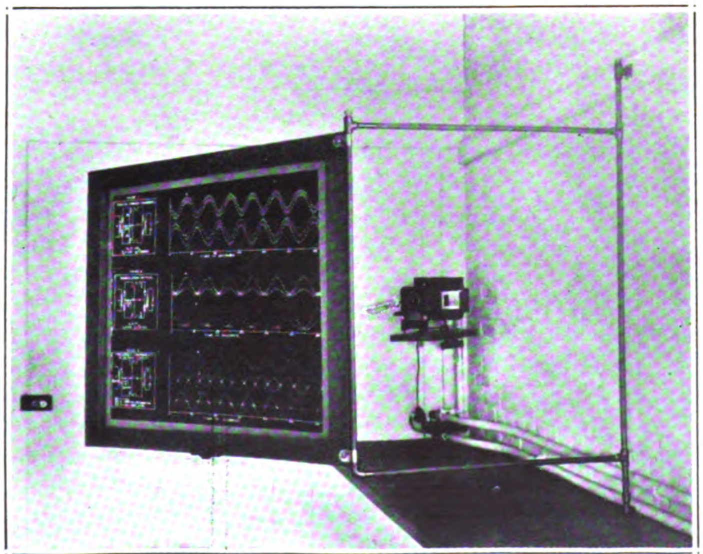


FIG. 2. *Close-up of the system ready for use.*

Chart Method

One method of presenting such material is to have each student supplied with a copy of such a pictorial representation (map, diagram, photograph or whatever it may be) but the expense incurred is often prohibitive. A more successful expedient, from the pedagogical viewpoint, is to have a large chart upon which the entire class can concentrate its attention, under the guidance of the instructor. This method is in fairly general use but has several draw-backs. Besides the expense of preparing and maintaining such charts their use requires that the class-room have available a large amount of free wall space if several are to be used during a single lecture, they are cumbersome to handle and require a fairly complicated indexing system and a large amount of storage space when not in use.

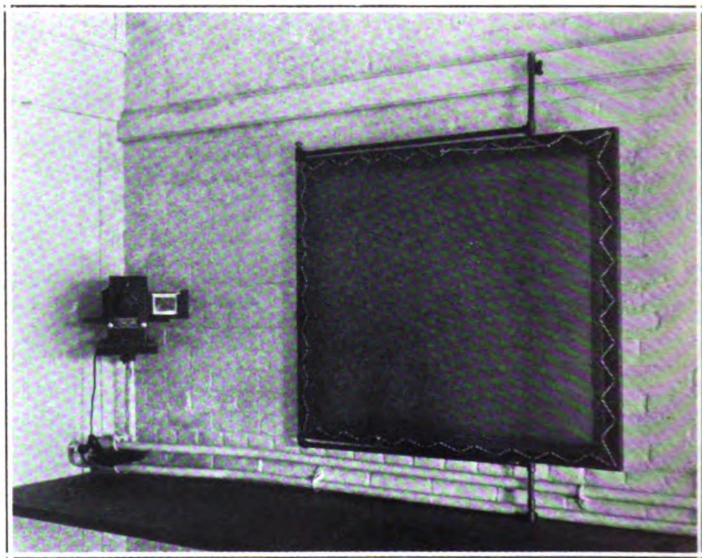


FIG. 3. *Shows the sleeve pipe frame mounting which permits screen to be folded back against the wall, thus occupying a minimum of useful space.*

Usual Lantern Slide Method

Consequently it has been found desirable to have the material made up in the form of slides for projection onto a screen of suitable size to be readily visible to all. Thus several objections to the use of visual material in the class-room are overcome but at the same time several undesirable features are introduced. The ordinary projection lantern must be placed at the rear of the room at some distance from the instructor, who must be at the screen to point out the significant details of the illustration. This then necessitates the use of a separate operator and some sort of a signaling system. Both these features are

undesirable, the first in that it involves the use of an assistant and the second in that the signals are disturbing to the class and so tend to distract attention from the subject under consideration. Another undesirable feature is the darkening of the room which is ordinarily required for successful operation. This has a depressing effect psychologically which is usually augmented by the resulting poor ventilation. Under such conditions the class will of necessity be less alert to grasp any new ideas which the instructor may be presenting. In addition, it is difficult for the instructor to intersperse black-board work with the pictures without a disturbing change in the illumination used. Finally, the instructor tends to lose contact with his class, enshrouded in darkness, and thus misses an opportunity for noting the effect of his presentation.

New Method: Daylight Screen and Short Focus Lens

In spite of these undesirable features of lantern slide projection they are a vast improvement over the former method of individual illustrations, or no illustrations at all, to supplement the word picture of the instructor. In order to eliminate the undesirable features but still retain the desirable ones we have arrived at the following method of procedure. Use is made of a daylight screen and a lantern equipped with a lens of short focal length. The daylight screen eliminates the necessity for darkening the room with its attendant evils which have been enumerated and the short focus lens permits the installation of the lantern at the front of the room close to the screen so that the instructor can both change the slides and indicate the salient features of the illustration being projected, thus eliminating the necessity for an assistant and the concomitant signaling system. Perhaps the most important improvement which this method brings about is the closer contact between student and instructor: the student is at all times concentrating his attention upon what the instructor is doing or saying and the instructor in turn has direct visual evidence of the effect of his presentation upon the class, collectively and individually.

An Application

The accompanying photographs illustrate one way in which this system is used. In Fig. 1 is shown an illustration of the system as used to demonstrate complex phenomena to a class in communication engineering. The crowding of the students is due to photographic limitations and is not an inherent defect of the system.

In Fig. 2 is shown a close up of the system ready for use. The lantern is mounted in one corner of the room and occupies space which would not otherwise be utilized. The light is obtained from a 110 volt incandescent lamp thus eliminating carbon troubles. The size of the screen is only 30″ x 36″ but this is entirely satisfactory for a class of twenty or twenty-five. Other sizes can, of course, be readily obtained. Due to the short focus lens the screen need be only four feet from the lantern in the present case. As is shown in Fig. 3 the screen is fitted to a pipe frame mounting equipped with sleeve bearings so that the screen can be folded back against the wall when not in use thus occupying a minimum of useful space.

Particular Applications

In addition to its application to work of the general character of that outlined, this system, with modifications, may be used to meet needs which are incident to a particular course. For example, a low-powered micro-projection attachment can be obtained which is useful for the study of micro-photographs of insects or plants or for the study of some types of metal structure where only low magnification is required. In our own work in Electrical Engineering it has been found extremely useful for projecting, by means of an oscillograph similar to that used to obtain the slides in the above photographs, an instantaneous picture of the changes in amplitude and wave-form of voltages and currents in electric circuits as any component of the circuit is varied. In no other way can a mental picture of the processes involved be so readily obtained.

ELECTRICAL DESIGN VERSUS HUMAN FALLIBILITY

(*Continued from page 18*)

false operations appear as the more serious "smashes," burns and shocks. Justly it must be said that the average of his performance is exceptionally fine. In emergency conditions "with hell a-popping," the wonder is that so great self possession and so little error results. Only the careful selection and training of men and conscientious effort and devoted preparation on their parts, can account for it. Nevertheless, there are failures. They have very serious results. As system capacities grow to the present day tremendous figures, extent of damage during failures increases. The effects of energy released in a short circuit are comparable to those of the explosion of a good sized shell.

What kind of work and operation gives rise to conditions under which these human failures occur? It may be at once stated that under normal operations of starting and loading apparatus there is not much chance of false move. In shutting down, however, we hear frequently of the opening a knife blade disconnect under load with disastrous consequence. In killing circuits for maintenance, inspection, repair or alteration there is exceptional hazard in the station of older design. Some of the most serious cases have been caused by procedure to wrong apparatus after proper protective precautions have been applied to the correct apparatus intended for the work to be done. Temporary grounds for protection of workmen have been applied by hand to live circuits. This is a frequent mistake. These are all illustrative of the result of human failure.

The immediate nature of the failure and the underlying cause is sometimes hard to determine. One fatal accident in which a very promising young electrician was burned so badly as to die in a few days, was found as probably due to a quarrel with his father over the father's early remarriage after death of the mother. Analysis of such cases is an extended study and cannot be detailed here. The illustration is given merely to indicate that no matter how able the man and thorough his training, there will be occasions when his mind will fail to function.

The Purposes of the Automatic System.

This unpredictable human failure is responsible for the necessity to protect both operation and operator. The designer, therefore, first lays out the switching scheme necessary to accomplish the normal operating control of starting, stopping, load division, protection against overload, etc. Then he visualizes the construction program with help of the construction planners, providing such sectionalizing and segregation as may be required to allow operation of electrically adjacent equipment during construction period. Next, he visualizes the maintenance

(*Continued on page 42*)

Electrical Engineering

E. E. DEPT. GRADUATE LECTURES

It has been the custom in the Electrical Engineering Department for several years to have annually a series of lectures for the benefit, primarily, of the graduate students. The lecturers have been experts in their particular fields and the subjects have been varied during the year and from year to year cover the many branches of the electrical art. The staff and undergraduate students are also welcomed at these meetings and occasionally members of the staff of the neighboring utility companies etc. are given invitations to attend and participate in the discussion.

The first lecturer in the series this year was Mr. L. A. Hawkins, Executive Engineer of the Research Laboratories of the General Electric Company at Schenectady. His subject was "Types of Men in Research." He pointed to the multiplicity of fields in which research must be conducted by an organization as large as the General Electric, the nature of the problems on which they are currently engaged and the mental attitude and personal qualifications expected of those who are engaged for such work.

Another lecture in this series was given by Mr. S. K. Wolf, Engineer, Electrical Research Products, Inc., of New York, and formerly a member of the Electrical Engineering staff of Yale. His subject was the "Talking Movie," and he described the technical foundation of the various types of talking motion-picture systems in use and projected. He dealt also with the difficulties encountered in installation and operation, the problem of rapid recruiting and education of the field staff and some of the future prospects of this new branch of the electrical industry.

Still another lecture was given by Mr. John S. Ware, Assistant General Superintendent of Distribution, Public Service Electric and Gas Company, Newark, N. J. Mr. Ware's subject was "Preservation and Conservation of Wood Poles." Items taken up in the course of his presentation were the relative merits and availability of the various kinds of timber for pole application, the yearly requirements of the country, the various types of preservative treatment and the processes involved, with the results obtained from them. The most recent lecture was one by Dr. M. F. Skinker, Assistant Director of Research, Brooklyn Edison Company, Brooklyn, N. Y. Dr. Skinker discussed the electrical linemen's rubber glove as a special problem in the field of dielectrics. The presentation dealt with the origin and properties of rubber, the combining process (fillers, vulcanization, deterioration) and also the fabrication into high voltage gloves, the specifications for their test, physical inspection, mechanical and electrical components of the test, the experience of the companies in connection with accidents and the technique of safety work in the electrical industry.

Other subjects contemplated in the series deal with the problem of "Ball Bearings in Motors," "Recent Developments in Motor Control," "Lighting of Airports and Airways," "Redesigning a Watthour Meter for Better Characteristics," "The Efficacy of Inducement Residential Rates."

Mathematics

At the February meeting of the American Mathematical Society in New York City papers were read by Professors Pierpont and Wilson and Dr. Rawles.

Recent speakers before the Mathematics Club have been Mr. Arne Fisher of the Western Union Telegraph Company, Dr. H. P. Robertson of Princeton University, and Professor H. B. Lindsey of the Yale Physics Department.

Mechanical Engineering

Professor L. C. Lichty attended the Annual Convention of the Society of Automotive Engineers, which was held at the Book-Cadillac Hotel in Detroit, Michigan, from January 15 to 18. He delivered a paper on "High Compression and Anti-Knock Fuels" which discussed the economic relationship between the cost of anti-knock fuels and the value of high compression and the factor of carbon removal.

The eighth season of the series of Mason Laboratory Moving Pictures, held on Wednesday evenings, at 7:30, from January 23 to February 27, inclusive, has proved, as usual, a very successful venture. The meetings have been unusually well attended, averaging about 200, and the interest of the audiences has run high.

Professor H. L. Seward has been interested, with Captain Q. B. Newman, U. S. C. G., in the design of the five new electric drive Coast Guard ships being built at Fore River. On Sunday, Janu-

(Continued on page 34)

Zoology

Professor Woodruff, who has been granted leave of absence from the University for the second term, is now in residence at the National Research Council in Washington, D. C. His work as Acting Director of the Division of Biology of the National Research Council will bring him in association with many of the leading biologists of the country.

During the past month the following individuals have left the laboratory, after having completed their period of research here:

Mr. Ivan Filipjev, an expert nematologist, who has been conducting researches upon the life history of worms; Professor Brien of Brussels, who has been engaged in the investigation of experimental technique as conducted in this country, has returned to Brussels; Mr. Petar Martinovitch, who came to this Department as a Visiting Fellow after having been engaged in research at Syracuse University, has conducted a very interesting series of experiments upon invitro cultures of mammalian tissues. Mr. Martinovitch returns to Belgrade where he will continue his work begun here.

Mining and Metallurgy

Mr. Ulick R. Evans, lecturer at Cambridge University, England, delivered three lectures at the Hammond Metallurgical Laboratory on February 25, 26, and 27. The subjects of his lectures were as follows:

I. The Study of Thin Oxide Films—Passivity.
II. The Rusting of Iron.
III. The General Principles of Corrosion and Protection.

Chemistry

In connection with the movement started two years ago, for a memorial in honor of Yale's greatest scientist, Josiah Willard Gibbs (1839-1903), Professor of Mathematical Physics in Yale University, provision was made for a new and complete edition of his works, the more important of which had been out of print for some years. This edition, in two volumes, has recently been published by Longmans, Green and Co. under the title, *The Collected Works of J.*

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Astronomy

New Haven, Conn., March 10,—Professor Frank Schlesinger, Director of the Yale University Observatory, has been awarded an honor open to astronomers of all nations, the Bruce Medal of the Astronomical Society of the Pacific, according to word received here today. The medal is awarded to Professor Schlesinger for his work on photographic parallaxes in particular and his services in other departments of astronomy in general. It is in the gift of the Astronomical Society of the Pacific and is awarded on the recommendation of the Directors of the Harvard Observatory, Lick Observatory, Yerkes Observatory, Observatory of Berlin, Observatory of Greenwich, and the Observatory of Paris.

The medal will be presented to Professor Schlesinger at a special meeting of the Society which is to be called in this city on April 12. Immediately following the presentation, Professor Schlesinger will deliver a lecture on an astronomical topic.

Other societies and institutions have honored Professor Schlesinger for his contributions to astronomy. The French Academy of Sciences, in 1926, awarded him the Valz Medal; the Royal Astronomical Society of London, in 1927, awarded him its Gold Medal; and honorary degrees have been conferred upon him by the University of Pittsburgh, and Cambridge University.

Medicine

Through a grant recently made by the Rockefeller Foundation an opportunity is now available at Yale to conduct studies concerning the relation between disease in teeth and systemic disease. This fund comes to Yale largely through the interest expressed by Dean Winternitz for several years concerning the relation between medicine and dentistry.

Dr. F. d'Herelle was recently awarded the William Wood Gerhard medal by the Philadelphia Pathological Society. This medal is awarded for especial zeal in research, and prior to the award to Dr. d'Herelle there have been only two recipients.

The Yale School of Nursing has received a gift of $1,000,000 for endowment from the Rockefeller Foundation. Dean Goodrich of the Nursing School has recently received the Medaille d'Hygiene Publique from the French government in recognition of her contributions to the advancing of nursing.

At its meeting on January 9, 1929, the Yale Medical Society was addressed by Dr. Heinrich Pall, Director of the Anatomical Institute of Hamburg University. He discussed from the viewpoint of Biology the inter-relations of Adrenaline, Insulin, and the Sex-Hormone.

Dr. H. M. Marvin discussed the subject of "The Electrocardiogram and its Relation to Clinical Medicine" at a recent meeting of the Yale Medical Society.

A lecture on "Reading Disabilities and Difficulties in Children" was delivered before a psychiatry seminar group at the Sterling Hall of Medicine on January 18, 1929, by Dr. Samuel T. Orton of New York City, formerly director of Iowa State Psychopathic Hospital.

Dr. Edgar Moyer of Saranac Lake addressed the Surgical Clinic recently on the subject of "Light Therapy in Tuberculosis."

Geology

One of the most recent additions to the exhibits in Peabody Museum is a fulgurite, or lightning tube, formed where a bolt of lightning struck in a sandbank near Lake Congamond, Conn. The specimen was collected by Professor C. O. Dunbar, and has been installed under his direction as a habitat case in the Hall of Mineralogy, showing how the object occurred in nature. It is a gift of A. W. and Miss Mineola Miller.

Dean Charles H. Warren was elected last spring a member of the American Philosophical Society.

Alan Bateman is planning to attend the International Geologic Congress to be held in South Africa this summer. He will leave slightly before the conclusion of the college year in order to travel down the East Coast of Africa and to study in advance of the Congress the interesting ore deposits of the Belgian Congo and Northern Rhodesia. C. R. Longwell also will attend the Congress, and will spend about four weeks in Europe visiting localities of geologic interest, on his way to Cape Town.

R. F. Flint is planning to make a study of the glacial deposits in central Ireland and northern England next summer, in order to compare the behavior of the last ice sheet in eastern North America with its behavior in western Europe. He is also at work on a manuscript on

(Continued on page 34)

Civil Engineering

Professor Tracy, who is on sabbatical leave for the second term, started late in February with Mrs. Tracy for a tour of the southern and western states.

The fourth floor of Winchester Hall, originally given over to two large but rarely used examination rooms, has now been equipped exclusively for instruction in Engineering Drawing. The changes this year have resulted in greatly increasing the available space on this floor, which is now divided into four well-appointed drafting rooms, three offices and a filing room.

Professor Suttie and his class in sanitary engineering have co-operated with the Department of Public Health of the University in making a health survey of the town of Hamden.

A film entitled "The Upper Carnegie Building," illustrating the process of welding structural steel, was shown recently at a meeting of the Student Branch A. S. C. E.

The hydraulics laboratory in the basement of Winchester Hall has just been renovated and provided with much needed equipment. The Chester S. Lyman fund made the improvement possible.

Professor Suttie is the author of the one hundred and seventy-five page "Report on the Water Resources of Connecticut," published in February. The book was written for the State Geological and Natural History Survey and was issued by the State. It contains a mass of hitherto very widely scattered statistical data on rainfall, stream flow, and the public and private water supplies of the State. The report will furnish a basis for all future State activities in the field of regulation and control of its water resources.

Forestry

Announcement has been made of the establishment of a foundation for the advancement of applied forestry at the School of Forestry. This is made possible by a gift of over $200,000 from Charles Lathrop Pack, President of the American Tree Association of Washington, D. C. The purpose of the endowment is to advance the knowledge and practice of forestry in the United States through field investigations and experiments and through developing examples of applied forestry. The first work under the foundation will be a study of

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Yale Engineering Association News

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

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G. S. MOORE, '27 S., *Assistant Editor.*

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Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

This department is prepared by the Yale Engineering Association. The Editors of the YALE SCIENTIFIC MAGAZINE are not responsible for its contents.

The following two articles give the reader ample food for thought without further comment by the Yale Engineering Association editor. Things are moving at Yale and our School is holding its position close to the front.

PROGRESS OF THE SCIENTIFIC SCHOOL

THE handicaps of the Sheffield Scientific School are being removed, slowly but surely. Its problems are now fully recognized as University Problems and their solution constitutes a prominent part in the very active advance which Yale is making in many directions. Sheff. men are active in this matter, notably Mr. Frederick W. Vanderbilt, '76 S. The University Administration is squarely behind the school.

In the issue of the *Yale Alumni Weekly* of February 8th, there is an extended editorial comment regarding the generous action of Mr. Vanderbilt in securing for Sheff. the property of the Historical Society and thus paving the way for the completion of the Van-Sheff Quadrangle. In the same issue there is an article on this subject by Dean Warren to which our members are referred.

In President Angell's speech to the agents of the Alumni Fund, reported in the same issue of the *Weekly*, there is the following statement:

The Scientific School's Development.

"No small part of the housing problem bears on the Scientific School as you probably appreciate. I think you know that Mr. Frederick W. Vanderbilt erected the greater part of the buildings on the block where the Scientific School dormitories stand. Through Mr. Vanderbilt's generous cooperation we succeeded last week in acquiring the building and land of the Historical Society on Grove Street, thus giving us control of all the property on that block. For the first time in our history we are now able to look forward with confidence to the completion of the quadrangles on that square, plans for which were made many years ago. It would be difficult to exaggerate the importance of having the Scientific School able to house all of its students in appropriately beautiful and dignified buildings, and I feel sure that when this occurs, a large part of the feeling of unrest amongst the graduates of that school will disappear."

The plans for residential quadrangles in addition to Van-Sheff are also of interest to Sheff men as these plans provide for a grouping of undergraduate dormitories as close together as practicable. One or more of these will be close to Van-Sheff and will therefore break down all sense of geographical separation of the two upper undergraduate schools and will make possible the easy shifting of dormitory capacity to the requirements of one school or the other as the respective sizes of the two undergraduate groups may change. There even will be the possibility of residential grouping somewhat independent of scholastic grouping. Thus the advantages urged by the Association in advocating University dormitories will be accomplished.

This Association is also highly gratified by the assurance that freshmen will soon be properly housed.

A New South Sheffield Hall.

President Angell is also quoted by the *Alumni Weekly* as follows:

"Let me say one further word about the Sheffield Scientific School architectural ambitions. Not long ago the Scientific School alumni presented an appealing document to the Corporation on the subject of the old building at the head of College Street. They asked the Corporation to replace it with a modern structure of commanding design. Of course, the Corporation listened to the appeal and has had the problem carefully studied. I hope we shall be able in the near future to agree upon a design that will commend itself to all concerned, and, when that time comes, we shall expect the graduates of the Scientific School to find the money to erect the building."

The needs for this building for the general educational and administrative purposes of the Scientific School become more and more pressing. It is hoped that some Yale graduate is just waiting to see the plans before providing the wherewithal for a fine structure at this most prominent location left for development.

PRESIDENT ANGELL'S speech on Alumni Day contained the following statements:

The Scientific School's New Course.

"The Scientific School is expecting next year to offer its students opportunity in their two final years to specialize in applied economics. As far the larger part of their men go into business and industry, this provision seems highly appropriate and may be expected to augment the flow of students into the School. The first two years' work will bring the men into touch with fundamental science and with some at least of the aspects of engineering. The electives provide opportunity for contact with a reasonable amount of humanistic material. The applied economic field covered will represent such subjects as banking,

accountancy, taxation, marketing, industrial and commercial organization, etc. It may perhaps be said in reply to natural inquiries that the course is not in any sense a reincarnation of the old Select Course, nor will it create a mere business school of the prevalent collegiate type. It involves the introduction of very little material not already found in our curriculum, but it does involve organizing and systematically arranging this to make it educationally as helpful and significant as possible."

A Better Sheff Contact with Freshman Year.

"Despite our financial and architectural preoccupations, there are some important educational measures moving at Yale. The Common Freshman Year is going, this coming year, to make a change very much in the interest of the educational success of the whole situation. It is making the Freshman requirements more flexible. Among other things it will be easier for a man going into the Scientific School to arrange a satisfactory schedule."

This change in the Freshman requirements brings about another recommendation made by this Association in its original report to the Administration. Thus our findings are being put into effect insofar as found by the Administration to be practicable.

COURSES IN THE SCIENTIFIC SCHOOL.

[NOTE: *The following letter of Samuel Insull, Jr., 1921 S., continues the discussion started in our section of the November issue of this magazine. This discussion has aroused much interest and we desire to know of all such questions as arise in the minds of members of the Association regarding the value of the courses of study in Sheff. Questions and answers should be sent to the Secretary, Mr. Billings Wilson, 75 West Street, New York City.*]

PEOPLES GAS BUILDING
122 SOUTH MICHIGAN AVENUE
CHICAGO, ILLINOIS

January 28, 1929.

Billings Wilson, Esq., Secretary
Yale Engineering Association,
75 West Street,
New York, New York.
Dear Sir:

I am much interested in the discussion started in the last issue of the SCIENTIFIC MAGAZINE relating to the reasons for a boy to go to the Sheff Scientific School. I believe that many Alumni will profit by this discussion. I am disposed to think that many boys are led to select courses in industrial engineering or general science because they feel that such courses are more modern and, therefore, more useful than the older well-known subjects. Whereas, if I understand the situation correctly, there are a number of very modern and valuable courses which have developed in the old groups.

My personal experience is so pertinent that I take the liberty of citing it. I took a degree of Ph.B. in Mechanical Engineering in the Sheffield Scientific School and have since fallen into work of a general business nature in an institution of which engineering is the background, rather than into strictly engineering work itself. To be precise, I am serving in an executive capacity in a moderate sized group of small public utilities. I have found in this work that grounding in engineering fundamentals is far more important than a detailed knowledge of business procedure. Of course, the student can acquire such knowledge from a special business course. Unless he contemplates taking such a course, however, my experience would indicate that he would do better to acquire the training by experience soundly, than more or less sketchily from a few courses worked into an engineering curriculum. In conclusion, to the boy who contemplates executive or business work in an organization of which engineering is the background, a sound and detailed grounding in engineering is much better than a necessarily more superficial knowledge of both engineering and business.

Yours very truly,
SAMUEL INSULL, JR.

This letter brings to the front a conviction which is deep seated in the minds of many employers of college boys. No doubt, these men will read with much interest the personal experience of a recent graduate. They have found that the fellow who has learned a few things thoroughly, and in the process, has acquired habits of clear, accurate thinking and positive conclusions, is likely to progress faster than a fellow whose college work has been scattered over many subjects, even though the subject which has received the major study is not closely associated with the business in which the young man is employed. On the other hand, we surmise that temperament has a good deal to do with the adaptability of the course to the individual and that for some the briefer attention to each of many subjects may be the best procedure. This discussion will be continued in later issues by statements regarding the aims, purposes and characteristics of Sheff's courses other than Industrial Engineering.

In this connection it should be realized that a course in civil, electrical or mechanical engineering no longer means a dry course in general theory and technology. Furthermore, there are many up-to-date courses associated with these general subjects such as the following: Automotive Engineering under Professor Lockwood; Building Construction under Professor Crane; Chemical Engineering under Professor Curtis; Transportation Engineering under Professor Daniels. These are only a few of the modern courses which are available for Sheff students.

YALE TO EXCAVATE "SLOTH PIT" IN NEW MEXICO.

The Peabody Museum of Yale University, and the United States National Museum at Washington, acting jointly, will send an expedition on March 25th to New Mexico to excavate completely the extinct fumarole in which the fossil of the Yale ground sloth was found. Yale will be represented in the expedition by Mr. Fred W. Darby, in charge, and the National Museum by Mr. N. H. Boss. Ewing Waterhouse, of El Paso, Texas, one of the discoverers of the sloth, will assist the party. It has been agreed that all bones recovered will be divided between the Peabody Museum and the National Museum, with the understanding that, should another sloth be found, it is to go to the National Museum.

Near the town of Aden, New Mexico, lies the low cone of an extinct crater rising about 200 feet above the surrounding country. On the east side the crater rim is broken by a gap which forms a passage into the interior in the floor of which lies a seemingly bottomless pit. It was in this pit that the sloth now at Peabody Museum was found.

FORESTRY

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forestry as now practiced in the United States. The aim of the study is to determine how an educational institution like Yale may contribute to the progress of forestry, through experimental and demonstration forests and in other ways. The study will be conducted by Dean Graves.

The Twentieth Engineers' Memorial Address for 1929 was delivered on February 13 at Sage Hall by L. J. Arnold, Manager of the Crossett Lumber Company, Crossett, Arkansas. Mr. Arnold's topic was "The Accounting for Southern Pine." He discussed in a very interesting way the various problems involved in lumber manufacturing accounts, with special reference to the procedure followed by his own company.

Dean Graves spoke at the third New England Forestry Congress at Hartford, Conn., on February 1, and at the annual meeting of the Canadian Forestry Association at Ottawa, on February 12. He also attended the annual meeting of the American Forestry Association at Jacksonville, Fla., on February 27-28.

Professor Toumey was the speaker at the forestry meeting held in Representative Hall, State House, Concord, N. H., on February 19.

Professor Chapman was appointed chairman of the Committee on the Forest Program for New England at the third New England Forestry Congress.

Professor Bryant presented a paper at the annual meeting of the Woodlands Section of the Canadian Pulp and Paper Association on January 14.

Professor Record has been a frequent speaker, throughout the winter, at the meetings of the Nylta Club, a junior organization of the New York Lumber Trade Association. Professor Garratt also spoke before this group on February 1 and March 15.

MECHANICAL ENGINEERING

(*Continued from page 30*)

ary 27, Professor Seward arranged to take seventy-four men, including faculty members, graduate students, Naval R. O. T. C., members of the New Haven Rotary Club and local yachtsmen, on the U. S. C. G. Cutter Tahoe from New London to New Haven. This fine new ship was put through all sorts of maneuvers, both in the electric power plant engine room and from the navigation bridge. This ship embodies the best practice in marine engineering today, and might well be called a central power house gone to sea. The weather was perfect, and a very instructive trip was enjoyed by all.

The Yale Student Branch, American Society of Mechanical Engineers, held an exhibition at the Mason Laboratory on the evenings of March 15 and 16. On Friday evening, March 15, the Student Branch acted as hosts to the New Haven Section, A. S. M. E., and on Saturday evening, the 16th, the students and faculty of the University were especially invited. The general public were welcome on both evenings. The engines and all of the operating equipment of the Mason Laboratory were in operation during the exhibition, with students in charge, for running performances and efficiency tests, as in regular laboratory instruction exercises. There were special automobile tests under way, using the Mason Laboratory rear wheel dynamometer. Several novel features were included in the exhibition which was planned, and conducted entirely by the officers and members of the Student Branch.

On February 27, 1929, Professor S. W. Dudley attended the regular monthly luncheon meeting of the Meetings and Program Committee of the American Society of Mechanical Engineers, of which he is Chairman this year. The meeting was held at Society Headquarters, in the Engineering Societies Building.

Professor P. B. Brill conducted an inspection trip through the plant of the Seymour Manufacturing Company, Seymour, Conn., on February 14, 1929, for the benefit of members of his classes in M. E. 24, Industrial Management.

Professor L. E. Seeley attended a meeting of the Committee of the American Society of Heating and Ventilating Engineers on Rating and Testing of Low Pressure Heating Boilers at the Bureau of Mines, Pittsburgh, Pa., on January 6 and 7, 1929. The Testing Code was put in final form to accompany the Rating Code, both of which were presented and accepted several weeks later in Chicago at the annual winter meeting of the Society.

GEOLOGY

(*Continued from page 31*)

the Glacial Geology of Connecticut, which will be published by the State.

Professors Flint and Longwell, in connection with Professor Agar of Columbia University, have prepared a book of collateral readings to be used in the course of General Geology. The purpose of the book is to supply interesting reading that will supplement and further illuminate the subject matter in ordinary text-books of geology. The book will be printed for use next fall.

F. W. Darby, of Peabody Museum, and N. H. Boss, of the National Museum, will spend two months this spring in southern New Mexico in the region where the interesting fossil sloth was recently discovered in a fumarole. The two museums are sharing the expense of this work, which will probably continue for several years. The Department of the Interior has given them concessions in a region about 70 miles square, 45 miles north of El Paso, and it is expected that many interesting discoveries will be made.

CHEMISTRY

(*Continued from page 30*)

Willard Gibbs. The committee in charge of the reprint consisted of Professors William R. Longley and Ralph G. Van Name.

This, however, is only the first part of the plan. A commentary on these volumes is to follow and the work of preparation has already begun. The commentary will likewise consist of two volumes, corresponding with volumes I and II of the original text. Volume I of the commentary will deal with Willard Gibbs' writings on Thermodynamics, and will be brought out under the joint editorship of Professor F. G. Donnan of University College, London, and Professor Arthur Haas of the University of Vienna. Volume II will cover Gibbs' writings on other subjects, including Statistical Mechanics, Multiple Algebra, etc. It will be edited by Professor Haas.

These editors are men of great distinction in their respective fields of work and it is confidently expected that the commentary will prove to be very helpful and valuable to students of Willard Gibbs' writings.

The financing of both of these projects has been made possible through the generosity of Professor Irving Fisher of Yale.

Dr. R. H. F. Manske, a research fellow under the Eli Lilly and Co. fellowship, has synthetically prepared ephedrine sulphate, the accepted medicinal reagent for the treatment of Hay Fever. Ephedrine sulphate is now prepared from the Ephedra, a plant found in the Southwestern United States and in China. The plant is also known as Mountain Rush, as Brigham tea, and, in China, as Ma Huang. The alkaloid produced by synthesis from coal tar distillates is identical in every respect with the natural ephedrine. This is another example of a synthetic product which can be produced artificially in case the natural sources of supply should be cut off.

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GEOLOGICAL DIVINING RODS AND GEOPHYSICS

(Continued from page 10)

C. *Seismic Methods.* When an earthquake occurs in California, waves travel through the earth with high velocity and delicately poised seismographs are set trembling in Washington, Ottawa, London, or Peabody Museum, New Haven. The tremblings are recorded on pieces of paper that revolve by clockwork. The recorded curves tell not only the distance of the earthquake from the instrument, but also the exact time of the arrival of the waves. Some waves travel faster than others and therefore arrive at the instrument earlier. The heavier (denser) the rock medium through which the waves move, the faster their speed. Hence the relative time of arrival of the waves is an indication of the character of the material through which they travel.

This well known principle is made use of in the so-called seismic method of prospecting. A bomb of 150 pounds of dynamite buried six feet in the ground is exploded and forms an artificial earthquake. The waves travel through the ground as well as through the air, and can be detected about six miles away by a suitable instrument. The instrument records photographically on paper moving about four inches a second, the shock waves and a wireless record of the time of explosion. Thus, the distance of the instrument from the explosion being accurately known, the velocity of the shock wave can be determined. Sound travels 1,120 feet a second through the air, about 6,000 feet through surface rock, and about 16,000 feet through salt domes. If a salt dome lies hidden between the instrument and the explosion point, its presence is therefore quickly indicated. Since salt domes in certain regions commonly have oil associated with them, a place to bore for oil is thus indicated. Still another use is made of the shock waves. Certain surfaces reflect shock or sound waves as surely as an echo is reflected from a canyon wall. Consequently, faults, or the boundaries between different kinds of rocks, reflect the shock waves and betray their presence to the recording instrument. And from such reflections obtained from several stations, the geologist may deduce the location of certain kinds of structural arrangements of rocks which from experience he knows are favorable for the accumulation of petroleum. A place to bore a test hole may thus be indicated.

The seismic method, as may be gathered, is used for finding oil. Its development is still in its infancy but already it has largely displaced the more complicated and cumbersome gravitational balance. A number of salt domes have recently been discovered by its use in the Gulf Coast region of the United States. Its usefulness has so impressed important oil companies that they are spending hundreds of thousands of dollars in seismic surveys. Much research remains to be done on it, but in the future this method undoubtedly will be made to give the geologist more valuable information regarding subsurface geology than he can now obtain. In most cases, principles conceived without thought to their practical application are later applied to the benefit of industry and Man, but in the case of the seismic method its development under the stimulus of pecuniary reward should later redound to the benefit of earth sciences.

D. *Magnetic Methods.* The attraction of the compass needle by the earth's magnetic field has long been known. Likewise the attraction of lodestone to steel is familiar to everyone. A coil of wire rotated in the earth's magnetic field generates a current. These fundamental properties are applied in a variety of ways, so there result a multitude of divining rods of different types.

Some metallic ores are like steel in that they are not only magnetic but retain their magnetism. Others, like soft iron, can be readily magnetized but do not retain their magnetism. Remove the cause and the magnetism disappears or changes its polarity and direction.

If a compass needle, instead of rotating horizontally, as is normally the case, be suspended vertically, it will point downward a certain amount for each part of the earth's surface. If, then, one carries such a needle over the surface and its inclination increases, it indicates the presence of an attracting body beneath. Likewise, a horizontal needle is deflected from its normal magnetic north position. Thus, deposits of magnetic iron are readily detected, and this is also true of other minerals with magnetic properties. This type of geophysical prospecting is the oldest but is suitable only for detecting the presence of an abnormal excess or deficiency of magnetic material in the earth. However, many ore deposits have been discovered by its use.

Another method measures variations in the direction and intensity of the earth's magnetic lines of force, rather than the actual values. Thus underground bodies, such as mineral deposits, that disturb the earth's magnetic field, may be detected.

Still another method consists in rotating a coil of wire in the earth's magnetic field in much the same way the armature of a dynamo is rotated between the poles of magnets. The current so generated is measured by a galvanometer or other suitable means. If mineral deposits containing magnetic ores in excess or deficiency from the normal are present, the variations caused by them are indicated.

Thus the dreams of the early philosophers have come true! But of magic, there is none save to the ignorant. Modern science has yielded principles born in the scientific laboratories without thought to their usefulness; scientists have bridged the sphere between the laboratory and industry and have visioned their applications. There have resulted new types of divining rods of immediate value to industry and science and of an ultimate value which cannot yet be foretold.

Veritatem dies aperit.

BRITISH EXCAVATIONS IN TRANS-JORDAN

(Continued from page 14)

Hellenization. Hadrian stirred Jewish national and religious feeling to the depths by undertaking to rebuild the temple in Jerusalem as a pagan shrine. The result was the fiercest of all Jewish revolts, the last stand being made at Bittir, between Jerusalem and Jaffa, where Bar Cochba held out long enough to mint a considerable coinage, some of the coins being still preserved in our museums.

The Early Christian Era

Again the inscriptions of Gerasa come to our aid. Hadrian himself spent the winter of 132 A. D. in the rich Graeco-Roman city, accompanied by a detachment of the Imperial Roman Guards (Equites singulares), a troop of cavalrymen of Roman birth corresponding to the Imperial Horse-guards in London. These also set up their statues and inscriptions in the city of their temporary residence, one of which was discovered there just before the Great War. New light on the history of Rome's struggle to hold and civilize the East may be expected continually as excavations progress back of the Christian period to that which here stands in direct contact

(Continued on page 36)

BRITISH EXCAVATIONS IN TRANS-JORDAN

(*Continued from page 35*)

with it, the period of its struggle with the Empire under the Antonines down to Marcus Aurelius, a period when Gerasa reached the acme of its splendor.

The Christian basilicas with whose excavation the Yale-British Expedition is now engaged belong to the last years of the fifth century. Superb mosaics from portions of the ruins which could not otherwise be preserved are about to be transported to the Yale Art Museum, where facsimiles in color are already on exhibition. Much has also been told of the uncovering of one of the great Christian holy places of Syria, visited by pilgrims from far and near to witness the annual miracle of the changing of water to wine on the anniversary of the miracle of Cana. Epiphanius, bishop of Cyprus, writing in 375 A. D., describes this rite inherited from pre-Christian times in sanctuaries of Dionysus in many parts of Syria, another sanctuary besides Gerasa's being that of Petra. The date of the festival was the Epiphany of Dionysus in the night of Jan. 5-6. The court and fountain adjoining the "Martyrium", in which Epiphanius describes it as taking place, have now been laid bare, together with the apparatus of stone and lead pipe by which the substitution of wine for water could be effected. But the court in which the ceremonial took place is now located between two basilicas, that of St. Theodore on the west, now fully uncovered, dating from 496 A. D., more than a century after Epiphanius wrote, and an earlier and larger basilica, on which work will be begun in the present month. This larger church, to which the Fountain Court formed only the atrium, is doubtless the Martyrium of Epiphanius' day. It stands between the Fountain Court and the pagan Nymphaeum, or public fountain, which formed one of the most magnificent architec-

tural features of the city, and was also dedicated, no doubt, to religious observances. The Nymphaeum was supplied with water for its central bason through eleven sculptured apertures from the same water mains as the Fountain Court. In other words the complex of buildings around the fountain exhibits a continuous development from pre-Christian to Christian times.

The fragments of a long inscription, now for the first time completely restored, tell of the change from pagan worship to Christian when the "flawless house" was erected by the "pious priest" (bishop?) Eneas in 496 A. D. in honor of St. Theodore, a Syrian martyr of 320 A. D. But this was only a middle link. When the excavations of March-June 1929 are completed we may expect to see the archaeological chain complete in successive architectural links extending from the Nymphaeum of pagan worship in the days of Marcus Aurelius down to the period of Christian revival just before the Mohammedan conquest of 631.

Yale Secures Treasures of Antiquity

It need hardly be added that the transportable objects of bronze, glass, iron and clay, which a generous agreement with the native government allows to be brought to the Yale Museum are already sufficient to make an interesting exhibit in the new room assigned to Early Christian and Byzantine Art, and may be expected very soon to rival in interest the rich collections of the Babylonian Art Museum. An intermediate link will be formed by the material soon to be shipped from the far larger and better equipped expedition to Doura-Europus. This field also, which Yale is occupying in cooperation with French archaeologists, belongs to the Seleucid and Graeco-Roman period, for Doura, like Gerasa, marked a station on the great oriental caravan route. The history of the two cities overlaps in its middle period, but with the difference that Doura was a great fortress, defending the crossing of the Euphrates, and (so far as yet appears) untouched by Christian influences and culture, whereas Gerasa's later history is bound up with the development of Christianity from its very beginnings.

MANAGING MEN AS AN ENGINEERING PROBLEM

(Continued from page 12)

with monetary units by mathematical processes, not subtleties of human nature. While the course in Personnel Problems in the Senior year and the course in English Literature in the Junior year deal with problems of human nature, there has been no course in the Sophomore year which does. Next year, in order to provide continuous contact with problems of human nature

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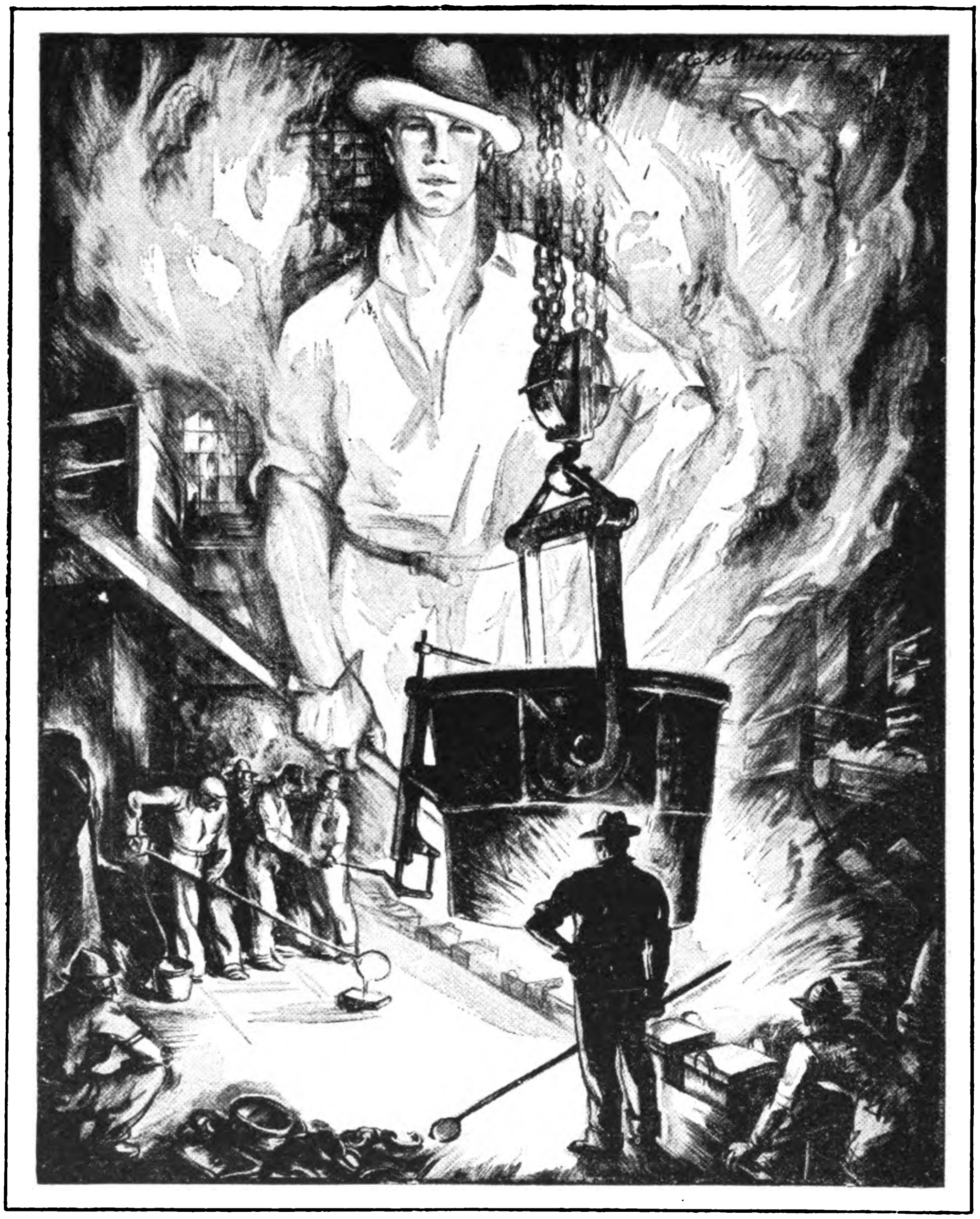

MANAGING MEN AS AN ENGINEERING PROBLEM

(Continued from page 37)

throughout the three years of study in Industrial Engineering, the curriculum of the Sophomore year will include a required course on problems of government and politics. This course will relate to problems of government or politics in the United States or foreign countries, selected so as to give the students broad exercise in discussing problems of the interrelation of people in organized political activity and a broad understanding of the principles involved. Some study of the interrelation of government and industry, including problems now active in this country, will be made. This, however, will be subordinated to the fundamental purpose of the course of developing an understanding of human relations in government that will contribute to a better understanding of human relations in industry, and thus take its part in preparing students for the assumption of executive responsibilities.

While the course in Industrial Engineering is especially designed for men planning to become executives, the importance of training in the management of men is also being recognized in the curriculum of the specialized branches of engineering. Next year a half year course in Personnel Problems for Engineers will be required of all Civil and Building Construction Engineering Seniors, and will be open as an elective to all other Engineering Juniors and Seniors. This course will be similar in method and subject matter to the course in Personnel Problems required for Industrial Engineers, but will relate especially to the problems of human contact which are likely to come to an engineer. Like the course for Industrial Engineers, it will aim to give an effective attitude and method of approach in regard to the human problems of industry.

THE PIGMENTS PRESENT IN GREEN LEAVES

(*Continued from page 16*)

while obtained from plant leaves, chiefly nettle, differs from the naturally occurring chlorophylls in that it has been treated with acid which replaces the magnesium in the molecule with hydrogen. When the hydrogen in turn is replaced with copper, a beautiful green pigment results. As a coloring matter, this copper derivative has the advantage over the natural pigment in that it is entirely light stable. When peas and other vegetables were prepared for canning in copper kettles, the green color was preserved remarkably well, due to traces of copper entering into the chlorophyll of the tissue.

Chlorophyll Has Several Industrial Uses

Chlorophyll is used as a coloring matter in a variety of products. It can be obtained for such purposes in water-soluble, alcohol-soluble or crude wax-like technical grades. Schertz states "It is used to hide color and bleach cottonseed oil, olive oil and other seed oils. It is also used as a coloring in various food products. It is used to color stearin candles, leather, waxes, resins, pomades, and vaseline, and to hide the color of mineral oils. In the manufacture of soaps, it is added to hide the ordinary yellow color of the product and to give a brighter look or a green color. It is also used to bring back the color to olive oil foots. No doubt much of the color of many soaps is due to the green product resulting from the saponification of the chlorophyll originally present in the natural oils." Several years ago, the writer enjoyed the novelty of eating green bon bons and drinking lemonade which were both tinted with chlorophyll. The coloring power of these pigments is very great so that only minute amounts are required for coloring purposes.

Some European investigators have found chlorophyll to have marked therapeutic properties. Tablets of chlorophyll are on the American market as a result of their findings. It is claimed that chlorophyll has a stimulating effect upon the body cells, it stimulates the hemoglobin-producing cells, increases the power of the heart beat and that it reduces blood pressure. A number of studies have indicated a larger content of several of the vitamines in the green parts of plants than in the roots, seeds or in etiolated plants. However, the literature in this field is rather conflicting on many points and does not warrant general statements.

From this brief review of some of the chemical, biological, industrial and medical aspects of the pigments of green leaves, it can be seen they have many points of interest to research workers as well as to the general public. These pigments are so closely bound up with some of the most fundamental processes in the biological world that it is certain that research upon them will someday yield results of the greatest importance.

SOME ASPECTS OF ENGINEERING EDUCATION

(*Continued from page 20*)

facts. The result was the notable study, "Waste in Industry," which was the basis of an important part of his remarkable activities in the Department of Commerce which paved the way to the presidency. In practice he acted upon his own dictum; "Engineers should exert themselves in our national engineering policies or the next generation will face a lower instead of a higher standard of living than ours."

The training of the engineer cannot be effected in the four years of the technical school or college. His earlier training

(*Continued on page 42*)

SOME ASPECTS OF ENGINEERING EDUCATION

(Continued from page 41)

must be supplemented; after graduation he must continue to study and to grow either in the Graduate School of the University or in the Graduate School of Industry and practical life.

The engineering college fills only one part of the technical need. Our country needs the development and expansion of its technological institutes, its shorter courses, its night schools, to complete the symmetrical manning of our industries which foreign experience has proved so effective. All industries should take the initiative and interest in training men, both graduates and others, in a way in which the larger electric companies are setting the example.

And all of this is essential if we wisely and safely direct and use those new agencies and opportunities of life which are the large possibilities of our new mechanical and scientific civilization.

Traditional education and the universities have opposed the new type of training. In England the universities contributed little to technical education until recently. In France educational initiative was lacking and there was stagnation. In Germany technical education was opposed by conservative educators but they were overpowered by far seeing statesmen. In America collegiate education has apparently had little understanding or sympathy with newer types of scientific training. At Yale Science struggled for half a century before it won its place. Engineering has now succeeded to the mantle in the struggle for understanding, recognition and growth.

An eminent Yale graduate, an industrial leader, remarked several years ago "Yale is emphasizing Medicine, it now occupies the center of interest; but Engineering has an equal or greater part in human welfare and deserves an equal place in University development."

ELECTRICAL DESIGN VERSUS HUMAN FALLIBILITY

(Continued from page 29)

and periodic inspection and adjustment work which will be performed. The relocation of feeders, installation, fault location and repair of cables will introduce considerations of auxiliary or standby equipment and protection.

When this assembly of switching and auxiliary equipment is complete the question must be answered as to whether a sequence of operation shall be predetermined and compelled by interlocking features of design, or whether to depend solely on the operatives. The decided trend in the United States is toward the automatic sequence control and this is regardless of whether the substations are to be attended or not.

It is not the purpose here to attempt description of details of such systems, but a few of the purposes may be of interest. Some are:—

1. Establish a key control whereby only correct selection of an initial operating key is possible. Different keys are provided for each sequence.
2. Main oil circuit breaker must be opened before subsequent operations of disconnects can occur.
3. Circuit must be de-energized before protective working grounds can be applied.
4. Access to equipment cannot be effected until ground is on.
5. Circuit cannot be energized from any source while ground is applied.

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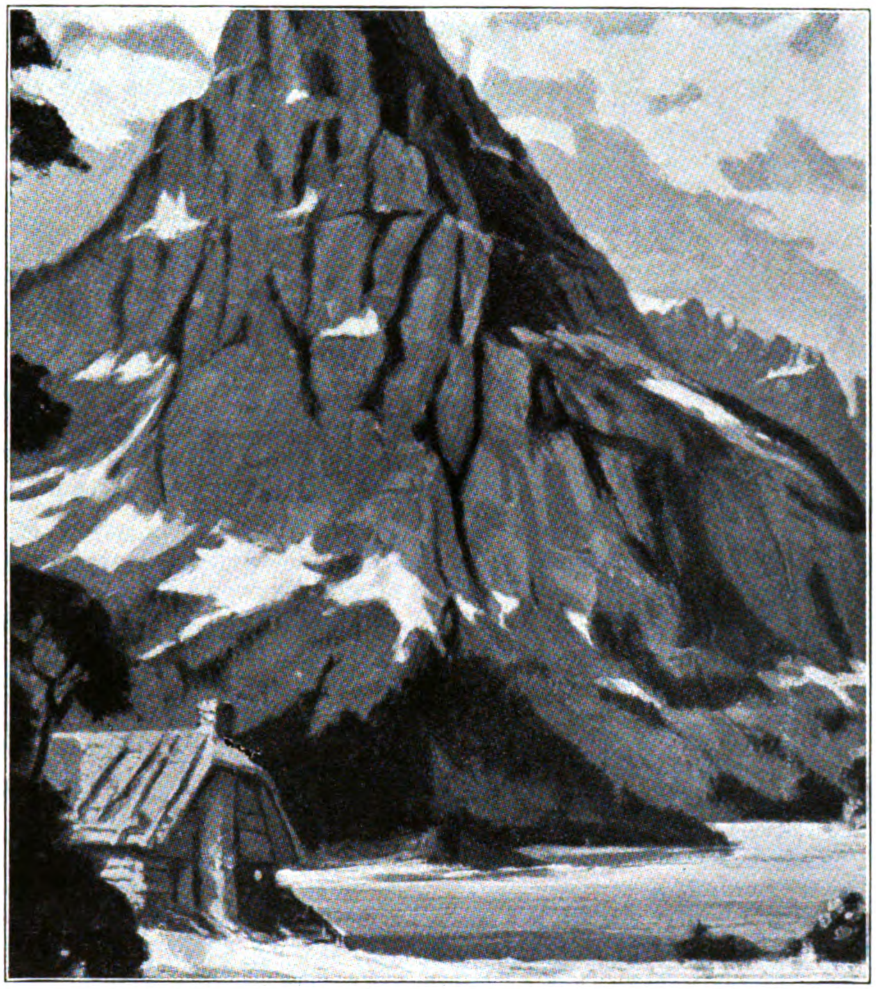


ELECTRICAL DESIGN VERSUS HUMAN FALLIBILITY

(Continued from page 42)

6. Mail oil circuit breaker cannot be closed unless all protective doors, etc., have been replaced in normal protective position.

These are but a few of the features given merely to illustrate the type of protection afforded.

Two essential features must be considered in such design. First, no workman shall find it possible to approach any piece of equipment until a protective working ground has been applied. This is the only absolute protection available to him against electric shock or burn. Second, dependence on negative indications not being absolutely dependable, the system must either depend on interlocking the application of ground with the main switch operation, or else there must be a circuit opening device of rupturing capacity sufficient to protect system in event of a wrong application of ground. Most system operators prefer to avoid the voltage dip and load swings of such short circuits even though they have full confidence in the ability of circuit protective devices and, therefore, appreciate interlocking. It is obvious that the device for applying the ground must be able to withstand the possible short circuit.

To illustrate devices which embody these features, Figures 1, 2 and 3 show the control room and elevating type of vertically phase isolating oil circuit breaker in use at Hudson Avenue Station of Brooklyn Edison Company. Figures 4 and 5 show the ground and test switch, operation of which is interlocked with that of main breaker and with compartment doors housing reactors.

To conclude, it is here stated as a thorough conviction based on observation and analysis of many accidents and their causes and effects, that we can no longer hope to avoid some measure of complication due to the application of interlocking schemes, but must accept this complication in order to obtain the added security and protection necessary to the modern electrical system.

THE MINE INSPECTION TRIP THROUGH CANADA

(Continued from page 22)

On the way south, three days were spent in going through the mine, mill, and smelter of the Chateaugay Ore and Iron Company at Lyon Mountain, New York, not far from Plattsburg. This mine is not of great size, but is noted for the fine quality of its iron. The ore is magnetite, Fe_3O_4, and its magnetic quality is utilized in the process of concentration preparatory to smelting. The material is crushed and passed over a magnetic pulley several times, and the valuable content, being retained by the pulley longer than is the waste, is separated therefrom. Automatic electrical control has been carried to the ultimate degree in this plant, and in all ways it is a well managed enterprise. The blast furnace, at the town of Standish, was being remodeled, and the party was able to stand inside of a furnace which is now active at a temperature of about 3500° Farenheit.

A few hours of driving took us from Lyon Mountain to Mineville, not far from Ticonderoga, where the underground surveying was carried on. The mines here are the greatest producers of magnetic ore in this country, but they produce only a small fraction of the total iron ore consumed.

The party made a map of a small section of the Barton Hill Mine by the three-tripod method, whereby foresight and backsight targets are on separate tripods, and transit-head is removed from its tripod and placed on that of the last foresight when stations are moved. Then tripod last occupied is used as the backsight, and previous backsight is moved up to the new foresight position. This saves much time in setting up the instruments. In spite of low-hung trolley wires and bad footing, no casualties occurred, and the trip came to a successful conclusion.

CHEMISTRY LABORATORY NOTES

(Continued from page 34)

Graduate Seminar—
Department of Chemistry.

The departmental graduate seminar is being addressed each week by some well known scientist either from industrial or academic circles. This is proving to be a valuable addition to the graduate curriculum, not only because of the scientific information which is obtained but also because of the opportunity it affords the students to meet leading American investigators in Chemistry. Undergraduates may attend these lectures. The speakers since January 1st were the following:

Professor E. Newton Harvey, Princeton University.
Dr. Hans Backstrom, Princeton University.
Professor Walter A. Patrick, The Johns Hopkins University.
Professor James F. Norris, Massachusetts Institute of Technology.
Professor John Zeleny, Professor of Physics, Yale University.
Dr. Walter S. Landis, Vice-President, American Cyanamid Co.
Professor James Conant, Harvard University.

During March the following have consented to speak:

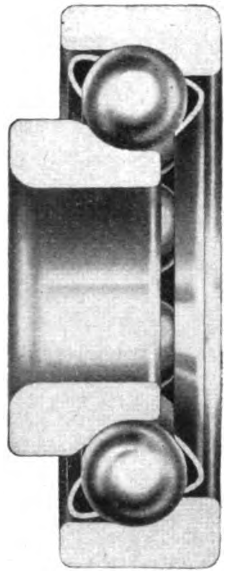
Dr. P. A. Levene, Rockefeller Institute for Medical Research.
Dr. K. G. MacKenzie,, Consulting Chemist, The Texas Company.
Professor E. M. Chamont, Cornell University.

Professors H. A. Curtis and B. F. Dodge are carrying on research on the carbonization of coal and on the preparation of methanol. Professor Curtis, who is especially interested in the study of the coal states that his ultimate goal is an artificial anthracite. Professor Dodge is working on cheap methods of producing methanol from water gas instead of from the present source, the distillation of wood. Methanol is important as one of the starting points in the production in bakelite, and in denaturing grain alcohol.

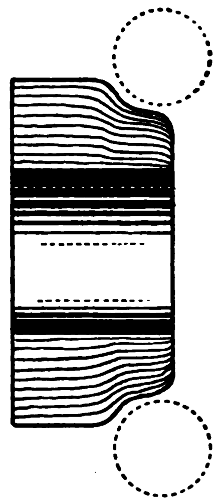
CONTRIBUTORS

(Continued from page 16)

¶ *C. R. Beardsley, '05 S., who has written an article in this issue on Accident vs. Human Fallibility, became an engineer of the General Electric Company after receiving his degree in Electrical Engineering at the Sheffield Scientific School. In 1911 he became Sales Manager of the United Illuminating Company at Bridgeport. In 1918 he took the position of Electrical Engineer for the Fred T. Ley Company, continuing in this position until 1923 when he became Superintendent of Electrical Construction for the Brooklyn Edison Company. Mr. Beardsley is vice-chairman of the Accident Prevention Committee of the Engineering Section of the National Electric Light Association.*



Half-section of New Departure Ball Bearing showing the contact between the balls and raceways.



Sketch of inner race after upset forging process. Note direction of fibre flow. Actual specimen does not show flow sufficiently clear to be properly reproduced.

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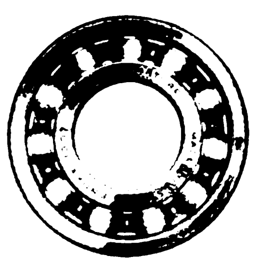

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THE YALE SCIENTIFIC MAGAZINE

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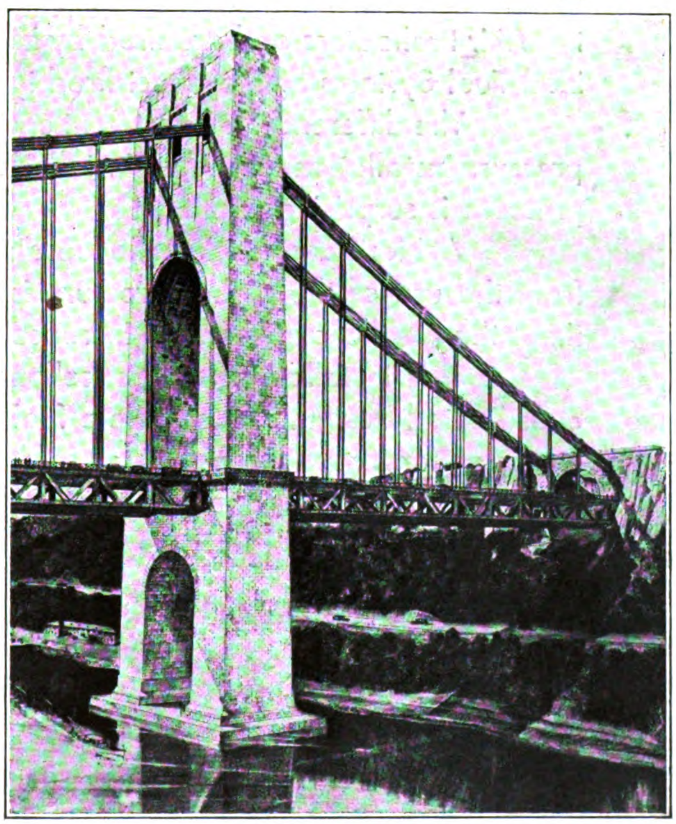

New Jersey End of the New Hudson River Bridge

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL

'RICE FORTY CENTS

THE YALE SCIENTIFIC MAGAZINE

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The Yale Botanical Garden and Preserve

Two Features of Yale's Botanical Work Which are not Widely Known.

By Professor G. E. Nichols

It seems strange, at first thought, how many Yale men not only lack information regarding these two Yale institutions but are entirely unaware of their existence. And yet, perhaps not so remarkable, after all. The seven-acre property now occupied by the Garden was bequeathed to the University by Professor O. C. Marsh, who died in 1899, "for the purposes of a University Botanical Garden." But in 1900 the newly-born Yale Forestry School took up its quarters in the old Marsh residence, which it continued to occupy until the completion of Sage Hall, in 1923. University catalogues to the contrary, notwithstanding, it was inevitable that the grounds surrounding Marsh Hall should become generally known simply as the "Forestry School grounds," and as such they still continue to be wrongly designated by many. The Natural Preserve, on the other hand, is a comparatively recent innovation, and the average Yale man, if he has heard of it at all, knows only that it is a piece of woods situated somewhere in the back country, far out beyond the uttermost confines of the Yale Bowl.

The Marsh Botanical Garden

By the first week in June the iris display at the Garden should be at its best, and it should furnish a worthwhile incentive for a walk up the Prospect Street hill, to where the Garden is lo-

Fig. 1. *A spring vista in the Marsh Botanical Garden.*

cated, about a block beyond Pierson-Sage Square. The iris collection is not a wholly new undertaking: it has been in the making for a dozen years. But the present formal iris garden was laid out less than two years ago, and since that time the number of iris varieties in the collection has more than doubled. Today there are approximately 150 varieties of the showy tall bearded iris and a goodly assortment of the intermediate and dwarf bearded types, which are arranged in a series of beds covering about a quarter of an acre of ground. The growth of the iris collection to its present proportions has been very largely made possible through the interest and support of Mrs. E. A. S. Peckham and Mr. John C. Wister, nationally recognized iris authorities, with whose continued cooperation the Yale iris display promises to become one of the finest and most attractive features of its sort in New England and one which will attract many visitors at this season of the year.

The iris display represents but one of many activities which are being carried on by this distinctive branch of the University, whose field of interest, as a Garden, properly embraces everything connected with the cultivation and propagation of plants. As a University organization, its greatest usefulness lies along the lines of research and public service. From the re-

Fig. 2. *The wild flower garden and greenhouse, with Winchester factory in the background.*

search point of view, the activities of the Garden are closely linked up with those of the two departments within the University having to do with the study of plants, namely the Departments of Botany and Forestry. Many of the problems of plant science are best worked out in the laboratory or in the field, but there are many for which the Botanical Garden constitutes the logical workshop. For several years past both the grounds and the greenhouse at the Marsh Garden have been increasingly used for this purpose, and at times the greenhouse facilities in particular have proven altogether inadequate to handle the amount of experimental work under way.

From the standpoint of public service one of the greatest opportunities of a botanical garden lies along educational lines. Its special mission in this respect might be described as teaching people what to grow and how to grow it. Aside from mere aesthetic values, a botanical garden can be of service to the public by demonstrating the cultural possibilities of various plants and groups of plants, together with the methods of treatment which are most favorable to their effective growth, productiveness, propagation and display. The nature and the number of the projects of this description which can practicably be undertaken at the Marsh Garden is of course limited. For the present, at any rate, attention is being confined to

certain phases of decorative gardening, which in itself is a field presenting almost limitless possibilities.

With a view to putting this general idea into effect, within the past five years many changes have been made in parts of the Garden grounds which before that time had remained—as the greater part of the property, in fact, still remains (Fig. 1)—very much as they were at the time of Professor Marsh's death.

FIG. 3. *General lay-out of the wild flower garden, as seen as it appears in winter.*

Several large trees have been sacrificed, considerable areas of low and poorly drained ground filled in and graded, and a large number of new display beds and paths laid out. During this time, in addition to the iris garden, a start has been made in the development of representative series of recognized ornamental plants. Among other things, there is a "Dutch bulb" garden containing a choice assortment of tulips, narcissus and the like. There is an "old fashioned" herbaceous garden. There are special beds for dahlias and gladioli, with from 75 to 100

FIG. 4. *The pond inside the wild plant and bird sanctuary at the Preserve.*

or more varieties in each. There is a striking display of Michaelmas daisies and another of phlox varieties—these two of special interest as illustrating the possibilities of native American plants in the hands of the horticulturist. And at the present time, along the lower slopes of the hillside upon which the greater part of the Garden is located, a rock garden is in course of construction.

But perhaps the most unique single development is the so-called "wild flower garden," or what might more properly but less conveniently be designated the native plant garden. Here, on a half-acre plot surrounded by a rustic cedar trellis (Figs. 2, 3), a systematic attempt is being made to demonstrate the cultural and ornamental possibilities of native American herbaceous perennials, planted under ordinary garden conditions or under conditions which can readily be duplicated in any garden. During the past five years more than 700 plants from virtually all parts of the United States have been tested out, of which between 400 and 500 have not only survived but prospered. Side by side, in the wild flower garden, may be found growing the yellow lady's slipper, the cardinal flower and the closed gentian from moist or wet Connecticut woodlands, the silverweed and the beach pea from brackish swamps or beaches along the seacoast, the prickly pear cacti and the sage brush from the dry plains country of the Middle-west, the dwarf alpine golden-rod and other plants native to the high mountain summits of northern New England. Here, during May and June, one may see in blossom a dozen different kinds of American irises; or, during late summer and autumn, some 35 different kinds of golden-rod, 30 different asters, more than a dozen different sunflowers,—all native American plants. And so on.

FIG. 5. *Showy lady's slipper at home in the sanctuary.*

In connection with the wild flower garden, experimental studies are being made in the propagation of native plants from seed; and, in this connection also, the seeds of many native American plants have been supplied to botanical gardens in other parts of the world. During this past winter, in response to requests, 340 different kinds of seed, more than 1500 packets in all, have been thus distributed among 37 different botanical gardens, situated in 20 different countries.

To a certain extent it is planned to develop at the Marsh Garden selected groups of shrubs and small trees: this as part of a general scheme formulated several years ago whereby, under the direction of Mrs. Beatrix Farrand, Consulting Landscape Gardener of the University, different parts of the University grounds are being utilized for the display of different groups of woody plants. But, for the most part, attention is being confined to non-woody plants. Even if it seemed desirable, the Garden would hardly afford sufficient space for the development of

(Continued on Page 42)

The Value of an Engineering Education

The Training of an Engineering School is an Asset in Business—Yale Should Train Employers Not Employees

By Calvert Townley

ORIGINALLY an Engineering Education was one which would prepare students to practice professional engineering. Upon this idea the courses of study of the Sheffield Scientific School and of other engineering schools was based. All engineers were divided into two classes; namely, Military Engineers, who were a part of the government forces, and Civil Engineers, who served industry. Military Engineers being educated by the government, practically all students trained in the technical schools were educated to be and were called Civil Engineers. As the modern demands for engineering service began to require specialists, Civil Engineers began to be divided into classes, and, as the duties of these different classes more and more widely diverged, more and more importance was attached to the class distinction and less importance to the distinction between Military and Civil Engineering. As a consequence, for many years past the original differentiation has been entirely discarded, and the various classes of engineers are designated by the kind of service they perform, as civil, mechanical, electrical, mining and so on, instead of according to the people who employ them. It was the last named classification that was used in establishing the original several engineering courses in Sheff, but the changed classification did not change the underlying thought, that students should still be trained to become practicing Professional Engineers.

The limited number of hours per day and the limited number of years which a student could devote to his training very soon made it clear that if a young man were to be even moderately well equipped for his chosen profession, he must specialize rigidly on these subjects which were most directly applicable to his own particular branch. Even then the hours and the years were insufficient, with the result that some educational institutions increased their requirements nearly, or quite to the breaking point of student capacity; while practically all schools eliminated from their engineering courses almost all subjects which did not directly apply to the particular branch of engineering in question.

The Engineer Enters the Field of Industry.

The next development was that industry began to increasingly recognize the worth of a trained engineer; first, by calling him more frequently into consultation for advice, and second, by drafting him into executive positions in administering its undertakings. At this latter point, of course, the professional engineer ceased to practice his calling as it had been previously understood.

With the rapid growth of such branches of industry for example, as manufacturing, transportation and public utilities, all more or less based fundamentally on engineering, the demand for administrators who understood engineering increased until, instead of a small percent, a great majority of the students trained in school to practice professional engineering did not, as a matter of fact, practice it at all, but on the contrary, found careers in industry. A survey of the activities of graduates from the engineering courses of the Sheffield Scientific School undertaken some ten or more years ago developed the surprising fact that, if my memory serves, only about eighteen percent of these graduates actually followed the practice of professional engineering. Obviously, therefore, the remaining eighty-two percent had spent much time studying specialties for most of which they subsequently had little if any use. Obviously, also, if the time spent on such unused specialties had been devoted to subjects which would have been of use in a business career, the students would have been just so much better prepared.

It had also become manifest in industry that many trained engineers who were successful in business were so, in spite of, and not on account of, their engineering training. Therefore, the impression gained ground in many quarters that as a class, engineers were narrow, and therefore many of them had very distinct limitations.

The Need of Modified Engineering Courses.

Recognizing the foregoing facts, the Sheffield Scientific School and some others undertook to apply a remedy by introducing new courses of study sufficiently comprehensive to ground the student in engineering fundamentals, but replacing many specialized subjects with others intended to better prepare him for a business career. I am informed that the popularity of these more recent courses, as evinced by the number of students electing to take them, has clearly indicated their value. Even these modified engineering courses have their limitations. Even in the non-engineering or so-called cultural courses there never has been a sufficient number of hours or years to instruct the student in all desirable subjects even when no engineering subjects were included; obviously, when some of the cultural subjects are replaced by engineering subjects, the lack of opportunity for broad general education becomes more acute. Undoubtedly, cultural training (languages, literature and history) is valuable to a man in establishing and maintaining his position in the world of affairs; therefore no consideration of the value of an engineering training for business would be complete unless in the last analysis its value relative to cultural training were considered.

My own experience in employing college graduates has been in an electrical manufacturing industry and in public utilities, both of which maintain engineering departments and to a considerable extent are founded on engineering principles.

The Engineer as an Executive.

It has been my observation that the fundamental difference between a student who has taken an engineering course and one who has taken a cultural course, is that the engineering student approaches his business problems from the quantitative viewpoint, while the cultural student is more apt to approach them from the qualitative viewpoint. Quantities of money, materials, time are the usual components of most business problems.

I acknowledge a debt to Professor George F. Swayne of M. I. T. and Harvard, that very distinguished engineer who occupied many positions of responsibility, for what has always appealed to me as a very apt comment contrasting the engineer

and the idealist. Swayne said "The engineer is the exact antithesis of the idealist. When confronted with a problem, the engineer approaches it with an open mind, proceeds to collect all the facts he can and then decides what to do based on these facts. The idealist, on the other hand, thinks first of the solution, and having picked out what he thinks should be the ideal one, thereafter proceeds to obtain the facts. If they do not fit in with his ideal solution, so much the worse for the facts." Needless to say, if the idealist's method were followed in business, only disaster would result.

The duties of a corporation executive, particularly in a large corporation, are to a great extent judicial. He must decide many widely varying questions. In order to do this it is necessary not only to have all the facts obtainable, but to properly evaluate or "weight" them. If all pertinent facts were obtainable, decisions would be simple. However, nothing in this world is ever 100% perfect, and that is where business or executive judgment comes in. An executive must use judgment in weighting the facts. The solution is not unlike that obtained by a mathematician who diagrams his forces by lines of different lengths lying at different angles with respect to each other. Then he constructs a resultant which is the geometrical sum of them all. Of course, this diagramming process is not followed in business problems, but the line of reasoning is the same, and the engineer's training in dealing with mechanical forces has a distinct value.

It has been my further observation that an engineering training tends to develop resourcefulness in emergencies. A man educated in the university of "hard knocks", although frequently competent in the line of his experience is more likely to get out of his depth when confronted with the unexpected. The engineer, on the other hand, has been taught to rely on himself. When he has a problem, even an entirely new one, he is supposed to solve it. The psychological effect of his training shows itself in an emergency. He is apt to say to himself—"If there is a solution, being on the ground and knowing more about the conditions, I ought to be able to work it out better than headquarters."

You will gather from the foregoing that I am a strong believer in the value of training in engineering fundamentals as a ground work on which to build a business executive. That does not mean, however, that I favor the highly trained specialist. The fact that over 80% of the students who took engineering courses do not practice professional engineering, instead of showing that "Four out of Five have it," shows, that "Four out of Five don't need it."

In this connection, I am tempted to refer to a suggestion I made some years ago as a member of a committee of the Yale Engineering Association which had been invited to appear before the Prudential Committee of the Corporation and present recommendations regarding Sheffield Scientific School policies. It was, and it still is my belief that Yale should make the most of all her resources, laying special emphasis on any peculiar advantages with which she may be endowed, and that she should not endeavor to compete with other educational institutions along lines in which they are best equipped. If that be a correct policy, what is the practical application of it with respect to engineering at Yale? To my mind, the practical application is this:—Yale has Age, Prestige, Standing and Atmosphere. Yale stands for Leadership. I think it was Casper Whitney who once wrote, "Yale may not always win an athletic contest, but the winner always has to beat Yale and knows there has been a

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OUR CONTRIBUTORS

Professor Herbert S. Harned, who writes on Chemistry and the Quantitative Method received his A.B., B.S., and Ph.D. degrees from the University of Pennsylvania. He was made Instructor of Physical Chemistry there, and was advanced to Assistant Professor and later to Professor. It was in the capacity of Professor of Physical Chemistry that he came to Yale. During the World War he served as Captain in Chemical Warfare, U. S. Army, both in Washington and in France.

Professor L. W. McKeehan, who writes on X-ray work in metals, received his B.S. degree from the University of Minnesota in 1908. After graduating he remained as instructor and did graduate work. He received his M.S. degree in 1909 and, in 1911, his Ph.D. He spent 1911 and 1912 at Cambridge University returning to teach again at the University of Minnesota. In 1921 he became a Research Physicist for the Western Electric Company. In 1926 he held a similar position at the Bell Telephone Laboratories. In 1927 he was appointed Professor of Physics and director of the Sloane Physics Laboratory.

John S. Nicholas received his B.S. from Gettysburg College in 1916 and his M.S. the following year. He was Instructor in Biology at Gettysburg and later Instructor in Anatomy at Pittsburg. He received his PH.D. from Yale in 1921. During the war he was detailed to the Vaccine Department of the Medical Corps. Dr. Nicholas is Assistant Professor of Biology. He writes on the recent developments in Biology.

Professor George E. Nichols, who writes in this issue on "The Marsh Botanical Garden" received his B.A. at Yale in 1904 and his Ph.D. in 1909. He has been Professor in Botany at Yale since 1926. Mr. Nichols is the Associate editor of "Ecology" and the American Journal of Botany and is a member of Sigma Xi.

Professor Winthrop M. Phelps, whose article on servicing the human machine appears in this issue, graduated from Princeton in 1916. He received his M.D. from Johns Hopkins four years later. In 1924 he taught for a year at Harvard. He joined the staff of the Yale Medical School in 1925 as Instructor in Surgery, and was promoted to Assistant Professor of Orthopedics the following year.

Dr. Malcolm R. Thorpe, who writes on the reconstruction work on the Brontosaurus, received his B. A. from Yale in 1913, and his Ph.D. there three years later. He was a member of the Yale Museum Expedition to Nebraska and Wyoming in 1914. He has also done work for the U. S. Geological Survey in South Dakota and Utah. He is now Curator at Vertebrate Paleontology at the Peabody Museum.

Calvert Townley, whose article on the value of an engineering education appears in this issue, was in the class of 1886 Sheff. where he received his M.E. degree. He started his career in Pittsburgh with the Westinghouse Electric Company. After ten years here, he went to Boston as manager of this company's activities in New England. In 1904 he was elected Vice President of the New Haven Road in charge of their electrifying projects. Later he went into the Kolynos Toothpaste Company as its President. In 1911, however, he went back with Westinghouse as assistant to its President.

Edward C. Wente, who writes in this issue on the principals of sound recording, studied at the University of Michigan, the Massachusetts Institute of Technology, and Yale from 1907 to 1918 where he received numerous degrees. After this he

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Servicing the Human Machine

Problems Confronting the Orthopedic Surgeon and How He Deals With Them

BY DR. W. M. PHELPS

ORTHOPAEDIC Surgery is that Branch of Medicine concerned with deformities and disturbances of function of the motor apparatus of the body. The orthopaedic department of the hospital, therefore, bears the same relation to the human body that the shop or garage does to the motor car. As the motive power of the body is constituted by the muscles acting on the joints and bones and their ligaments, and as these muscles are actuated by the nerves, the major part of the work is concerned with mechanical measures and apparatus. The orthopaedic surgeon can therefore be considered as a "human mechanic." This function, however, includes more than pure mechanics because of the fact that human beings cannot be

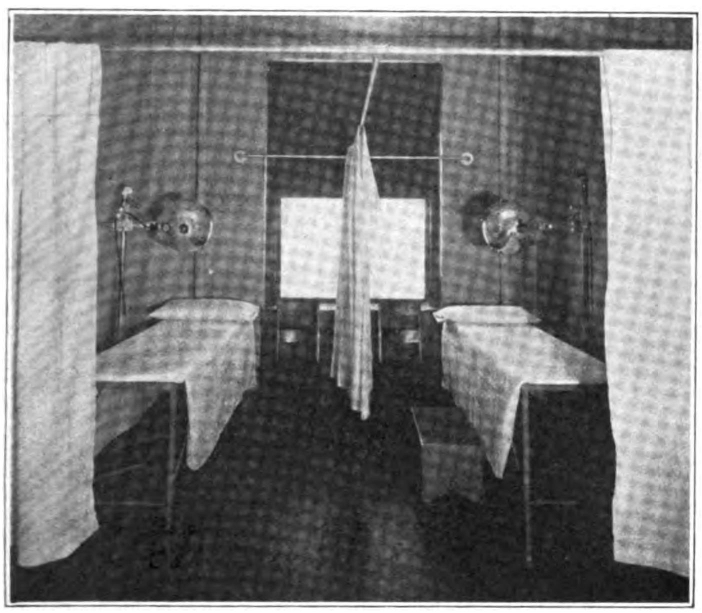

FIG. 1. *Ultra-Violet Treatment Room. Mercury-Vapor Quartz Lights.*

treated as a machine alone. The consciousness and personality play an important part in any treatment and must be taken into consideration.

However, the facilities to be used in dealing with deformities and motor disturbances must include much more than the operating room, and the orthopaedic surgeon must be familiar with many measures for treatment other than actual surgery. These measures are grouped under the term Physical Therapy. In the Physical Therapy Department must be trained therapists, working under the direction of the orthopaedist.

Uses of Various Types of Light Rays.

The measures used include the use of radiant energy, ultra violet and infra red, which have been found to have specific effects upon the body. The mercury vapor quartz light is used especially for a source of the shorter ultra violet light (Fig. 1), the carbon arc lamps for the longer ultra violet (Fig. 2), and the visible light and various types of heat generators for infra red (Fig. 3). The effect of ultra violet light is curative for rickets and also produces a general tonic effect on muscle and skin. The carbon

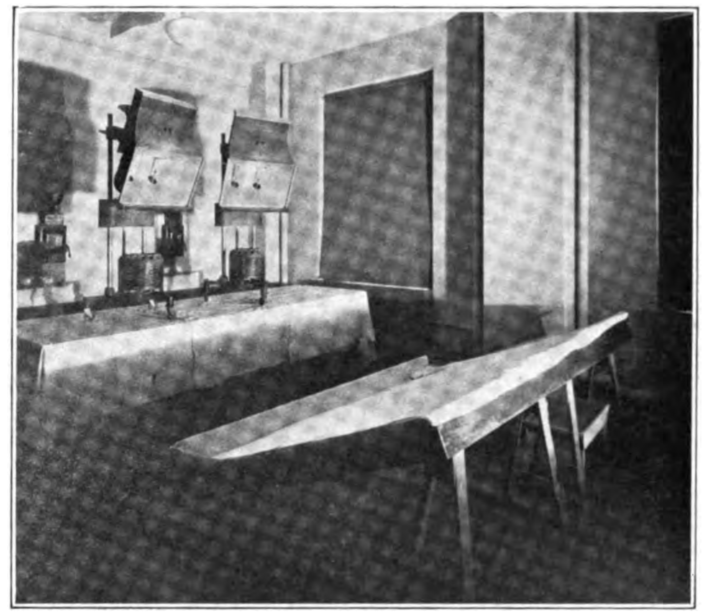

FIG. 2. *Ultra-Violet Treatment Room. Carbon Arc Lights.*

arc lights are especially useful in the treatment of bone, joint and glandular tuberculosis and the infra red or heat lamps pro-

FIG. 3. *Treatment Room. Infra-Red Light.*

duce an increase of circulation and general relaxing effect, very often desirable in the treatment of many conditions.

Massage and Mechanotherapy.

Massage is used extensively when indicated for the improvement of muscle power. Manipulations of the various joints are important but should only be carried out by skilled therapists for definite indications. There are also many forms of electricity used for their specific effects on the body tissues. Diathermy is a form of high frequency current of small amperage which produces local heat as it passes through the tissues due to their resistance. In this, it is not the electricity but the convenient form of the application of heat which is valuable. Other electrical measures are the various forms of high frequency, sine wave generators, galvanic and faradic currents, which are utilized mainly for their effect on the contractility of muscles and hence stimulating effect upon the circulation. Use is also made of water at various temperatures as a form of massage, in whirlpool baths for example, or for its stimulating effect, as in contrast baths, or to carry out exercises with the elimination of the gravitational field, as in exercises under water in a tank (Fig. 4). Various forms of vibratory apparatus are used as an aid to massage, for reaching certain parts of the body and under certain conditions. Exercise systems are extensively used for postural correction and general conditioning or reconditioning (Fig. 5). The basis, however, of good physical therapy is a thorough and complete knowledge of, and facility with, the various forms of both sedative and stimulating massage. To this can be added most of the other measures above as they are indicated in particular cases.

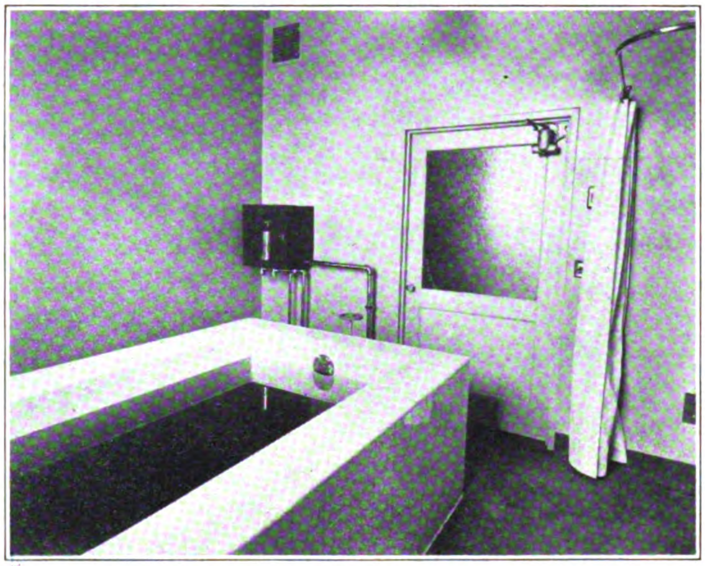

FIG. 4. *Tank room for under water exercises.*

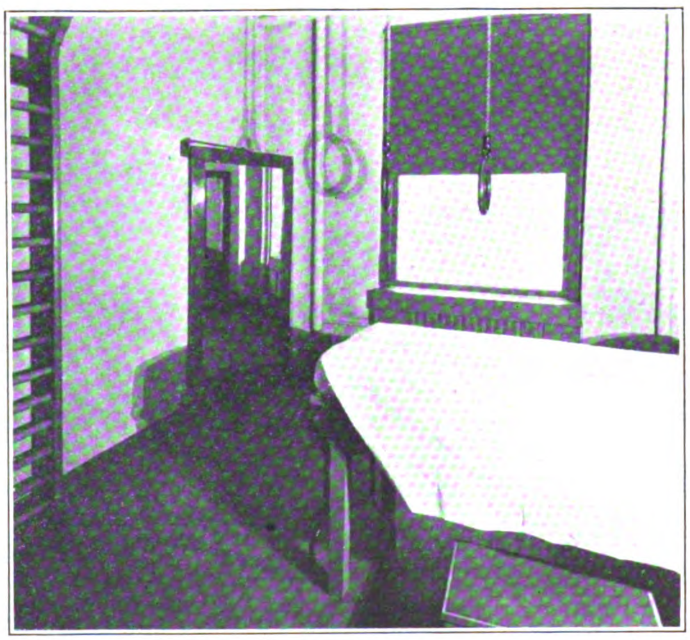

FIG. 5. *Gymnasium for postural corrective exercises.*

Braces.

Another essential to the orthopaedic service is a machine shop (Fig. 6). Braces and splints must be made to fit the individual patient. Their purpose is to take the place of paralyzed muscles or to assist weakened ones in their action. They must be fitted to the patient according to mechanical principles and all differences of size and shape and deformities must be allowed for. It is therefore practically impossible to depend on "stock braces." The materials used consist of various types of steel for rigid or spring supports. The body must be protected from the pressure of the steel by padded leather where necessary. In the case of very weak patients and children, lighter metal than steel must be used, and duralumin is coming into high favor as the various types of this metal are developed, and methods of working it are discovered. At present, welding of duralumin is unsatisfactory and much cutting and shaping is necessary. Processes of welding this metal are however being developed, which will aid greatly in its use in brace work.

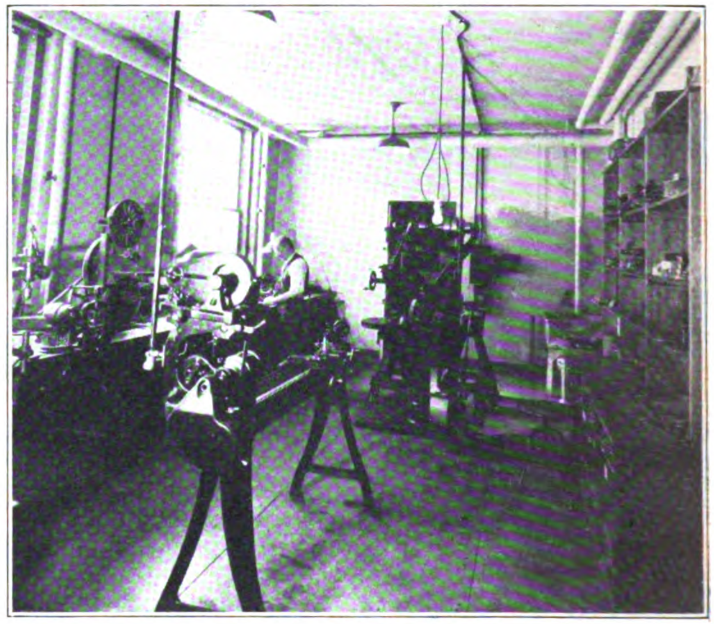

FIG. 6. *Machine shop for making braces.*

The braces used mainly are arm and leg braces of various types, with lock joints, right angle stops, etc.; back braces and foot supports of various kinds. Many can only be made by taking a plaster cast of the part and modeling the brace on the plaster mold. The essential machines for such a shop are a lathe, drill presses of various sizes, milling machines, band saw, various types of metal cutters and a forge. It has been found by experience that the coal forge is the most satisfactory, difficulties in maintaining proper temperatures and cooling rates being found with electric and gas types. There must also be various types of sewing machines for the leather parts of the braces.

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The Present-Day Trend in Biology

Some of the New Angles of Approach Adopted in the Sciences of Biology and Zoology and Where They Lead.

By Professor J. S. Nicholas

If we look back into the periods which constitute the background to present day biology, we find that the gross structures were described in the earliest study of animal form. Succeeding this, there is a second phase of investigation in which the finer details of structures were ascertained by the use of lenses and simple microscopes. Many of the correlations which were made between the finer anatomy and the gross anatomy were later to have a definite functional significance. Succeeding these studies there is a distinct trend toward the classification of all the animal groups. This period might be said to have been dominated by the spirit of Linnaeus. In it there were a large number of biological investigators who grouped and arranged animal forms. This period constitutes the climax of the classification era. Following the intensive classification of forms there was an analysis of the arrangement of animal groups in the light of facts uncovered by Paleontology, Comparative Anatomy, and Comparative Embryology. These branches of science showed many distinctive errors in the system of classification as it then existed.

All Branches of the Subject Interrelated

We now know that no one sequence of study will show all of the facts and factors which underlie fundamental concepts that have grown up in the science of Biology. It is interesting that no one of them alone can give a complete picture. It is also interesting that when they are combined they tend more to give a correct sequence than any one of them when taken alone. This is indicative of the trend which can be followed in modern biological study.

The present trend of biological study is one in which there is a distinct correlation of form and function. This correlation is brought about by the application of definite experimental methods to the study of the living organism. By slight changes in the form of the organism we are able to study functional correlations. The changes in form are made at an early period, generally before the formation of functional nervous system. There has been no opportunity for the materials which we change to impress themselves upon the nervous system or act in the formation of its functional pattern.

The experimental approach is old in every sense of the term. The observational method was not new to Aristotle but he lives in the science of Biology as well as in numerous other sciences as the founder and chief proponent of the observational method.

The modern mind demands a definite proof of theory through facts which are derived by observation from experiments. It is not satisfied with the simple observations from which a theory is derived or deduced and which has no experimental basis. An *arm chair* theory has little chance of acceptance or survival.

The modern era in experimentation cannot be said to have had a single founder but is associated with the names of a great many men who have made definite contributions to the science as it now is. We find such names as Trembley who worked upon the regeneration of lower forms, or Spallanzani who did the original experiments on digestion, associated with these early forerunners. These men had the experimental outlook in mind—men like Roux, Pfluger, Born, Claude-Bernard, and Pasteur. Roux is associated with the science of experimental embryology; Pfluger with the experimental physiology of the embryo; Born began grafting experiments in animals; Claude-Bernard was a leader in the general field of experimental morphology, with particular emphasis to the study of the endocrine or ductless glands; Pasteur placed bacteriology upon a definite basis from which experiments could be carried on. These men contributed not only facts, not only theories built upon their facts, but a definite technique or method of approach by which future workers could continue the work which they had begun and carry them to a much more demonstrable, intimate conclusion, than had the originators of the method.

The Ductless Glands

If we should attempt to trace the work which has grown out of the main topics given above, we would have to take more than the allotted space, for each one of these men has given rise to a whole sequence of work which is being carried on at present. One need only point to the perfectly tremendous amount of investigation which has grown out of the original researches of Claude-Bernard upon the ductless glands to emphasize the importance and magnitude of this work. It is only within the past few years that the endocrine secretions have entered the field of applied science. The coordinated researches of Banting and Best, Collip and MacCleod, built upon the work of MacCleod as a background have given us insulin, a compound isolated from the pancreas, now used in the treatment of diabetes; Collip has isolated parathyrin used in treatment of disturbed calcium metabolism; Kendall, Harrington and Barger have isolated thryoxin as well as synthesized it. Abel, a forerunner of all this chemical analysis, has isolated adrenelin and a pituitrin substance. These researches together with Kamm's recent work on the pituitary are all founded upon factors determined by biological investigation. We feel at times that the applied biological sciences have proceeded in their application of these substances without taking advantage of the biological background in controlling their experiments.

It is my purpose, therefore, to limit myself simply to one or two phases of experimental work which have definite bearing upon the theories of the present day. I would treat first the experimental analysis of nerve outgrowth and the expansions which have developed from this technique. At the time of its conception by Harrison, the problem of nervous outgrowth rested upon the facts derived from gross and microscopic analysis of the form of the nervous system. To show the relationship of the nerve fibers to one another and to the central nervous system, beautiful preparations had been made. None of them, however, were definite in their solution of the problem. No one could say that a nerve did not develop in an outlying peripheral field later to unite with the central nervous system. This Harrison was able to show by means of a crucial experiment. He developed the nerve tissues in culture medium outside of the body and saw the outgrowth of the nerve processes from single

cells. This constituted a crucial, an experimental proof of a fact which had been under argumentation for years, and which probably could not have been solved in any other way.

Following the development of the tissue culture method as a means for study of developmental processes, this work was continued in its various phases by many other workers in associated fields. Burrows was the first to refine the technique and was able to grow other types of tissues in culture. One of the results of his work showed that the heart beat is initiated without the presence of nerve fibers in heart muscle which is entirely isolated from the body. The individual muscle fiber is capable of beginning its rythmic activity without nervous stimulation. Carrel has carried the technique still further and is growing isolated cells which have been carried for more than a decade in culture medium. Lewis has been able to observe the fertilized mammalian ovum through the early stages of its development. The field is so large that the few examples here given will serve as adequate illustrations of the type of investigations initiated in applied biology by research methods evolved in the solution of the problems of pure science.

The experimental analysis of development has proceeded along slightly different lines from those given above. Since the initial work of Roux and Pfluger in analysing the reactions of the frog's egg, Born has given us a valuable method for analysis by grafting tissues from one embryonic organism upon another. In order to work out various concepts of development, forms must be used which will survive the experimental conditions under which they are placed. Born's original experiment consisted in splicing together two halves of frog's eggs. This was followed by Harrison's experiment in which he joined together the bodies of different species of frogs in order to study the effect of the one upon the other. This method has given rise to a tremendous experimental program, both in this country and abroad.

In this country it has been forwarded chiefly by Harrison and his students. Its chief aim has been the solution of various problems in the mechanics of development. The method has been carried into other groups of vertebrates in an attempt to analyze the conditions under which they develop. Within the past five years it has been possible for us to observe the mammalian embryo during its development and do certain operations which will lead us to a more definite knowledge of what is taking place during embryonic life. In mammals particularly this is most important. It is obvious of course that such an analysis is more of a physiological nature than of a strictly anatomical one. Their physiology is constantly changing; it never stands still. This also may be said of their morphology, but it moves at a relatively less rate than does the physiological action of the embryo. The correlation of the physiology and morphology, the form and function, of the embryo is a thing which we desire to attain.

White rats develop for twenty-one days within the mother. We are now able to operate upon the embryos at the tenth day of their gestation age. They are small, they are non-motile, they are just beginning the development of their various organs, which, however, are so well determined, so well constituted, that any change which is made in them is retained in the animal at birth. The results which we have obtained from this line of work show us very conclusively that the rat embryo has practically no capability for replacing parts which have been removed during its embryonic life. This is in sharp contrast to the capacity of various salamanders where a whole organ can be regrown (regenerated) after its experimental removal. Hooker and I have been able to trace through the regeneration which occurs after the cutting of the spinal cord in embryos of this type. These animals follow as nearly as we can determine, a perfectly normal sequence of development in spite of the absence of some of their tissues.

The second series of experiments which is now in progress at the Osborn Zoological Laboratory involves transplanting tissues from one rat embryo to another. In a way this is an enlargement of the tissue culture technique except that instead of growing tissues outside of an animal body, we are transplanting them from one embryo to a new location upon another and studying the growth of the transplant within the body of the second embryo. Thus eyes have been transplanted from one embryo to another of the same litter. Some of these transplants show definite development in their new locations, others undergo a distinct dissolution. The main problem which presents itself for solution is the determination of the factors which are causing the difference in growth between the eyes which develop and those which do not.

The transplanted eyes are far removed from a location in which they could function. It is not of prime importance at present whether they function or not. We are simply studying the factors underlying the development of tissues in a strange environment. The importance of this factor need not be emphasized here. The more we learn about the reactions of developing tissues, the more background is afforded for the interpretation of concepts which underlie the physiological morphology of the adult organism. We are ourselves essentially cellular individuals and in the action and reactions of the cell groups rests much of the solution of the problems of organic function.

Experimental methods have a definite effect upon the teaching of present day biology. Elementary teaching must be to some extent dogmatic; i.e. we must lay down fundamental concepts upon which a student can build without too much confusion as to the incidental and possibly contradictory details. It is true that dogmatic teaching occurs in all of our elementary work but it is also true that the amount of dogma has been reduced to an extent not believed possible ten years ago. The second effect of the experimental method upon teaching is that theoretical conditions are clearly labeled as present day concepts. The teaching of today places before the student the fundamental facts of pertinent observations upon which our main facts are founded. It is clear that a great many of these are subject to experimental modification later, that the concepts are not necessarily true ones, but are working hypotheses to which we may later add or subtract. The third effect upon teaching is that pure morphology, the study of structure disassociated from function, is rapidly disappearing from our curriculum. We still have fundamental morphological units upon which we base things. The units of structure have not changed but the adaptations of the different structures undergo modification.

Other Sciences Called Upon

The experimental method has had a definite effect upon the type of research which we are conducting at the present day. In the early days research led to further specialization in each one of the definite fields. As specialization progressed, combinations with other scientific fields were effected. Chemistry, Physics, and Mathematics are now being combined in biological research to an extent which is hard to realize. Statistical studies have assisted greatly in correlating facts derived from large numbers of observations. Mathematical formulae are

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Engineering Students Make Inspection Trip

Seniors in the Industrial, Mechanical, and Electrical Engineering Courses Take Annual Spring Trip to Visit Factories and Power Plants in the East

BY D. H. BLAIR AND J. R. SUTHERLAND, 1929S

ON the 27th of March, 1929, the combined groups of Industrial, Mechanical, and Electrical Engineers assembled in the auditorium of the American Telephone and Telegraph Company in New York City, embarking on a perfectly planned and arranged trip beginning at this point and, except for the Electrical group, ending a week later in Detroit, Michigan. After receiving a few brief but direct directions from our most thorough and congenial skipper, Professor H. L. Seward, we were introduced to Colonel R. I. Reese, assistant to the Vice-President, who acted as host and paved the way to the address by Mr. Gherardi, of the Bell system. Mr. Gherardi outlined and analysed the Bell system. After his talk we were guests of the company at a delicious luncheon, served in the same building.

After luncheon the Mechanical and Electrical Engineers visited the Bell Laboratories, the Industrial Engineers taking special buses to the Western Electric plant at Kearny, New Jersey, where they were addressed by several of the executives of the various departments, and later were taken on an inspection tour of the plant. The Kearny plant of the Western-Electric Company is in the midst of a period of great expansion and revision at present. Within a few years it will be modernized beyond its present condition.

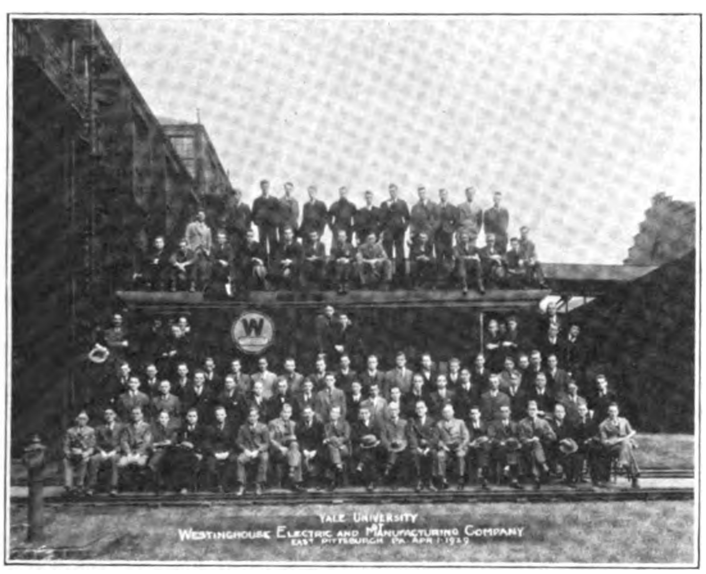

FIG. 1. *The entire group at the Westinghouse Company in Pittsburgh.*

Quite a few of us took advantage of the special rates at the Pennsylvania that night. Some went to bed and others went exploring, but everyone was on deck for the dinner with the Yale Engineering Association at the Yale Club. We were entertained royally and participated in a most delicious dinner as well as privileged to hear several speakers, among whom were O. S. Lyford, '90 S., and Professor E. D. Smith. The graduate aid and generosity in providing the best of everything for us was the very backbone of the success of the trip, and is more than deserving of our deepest gratitude.

Next day the Industrial and Mechanical groups visited the Wright Aeronautical Corporation at Paterson, New Jersey. Our first impression of the plant was its up to date and modern appearance, both inside and out. The entire plant as it stands is but six months old and is a startling example of the tremendous growth and expansion of the aeronautic industry. The product of the plant consists of three types of radial airplane motors, a fourth to be placed on production in May, and the *Typhoon* marine engine. The foundry was a remarkable surprise to us because of its unrivalled cleanliness. The Wright Company claims to have the most modern foundry in the country.

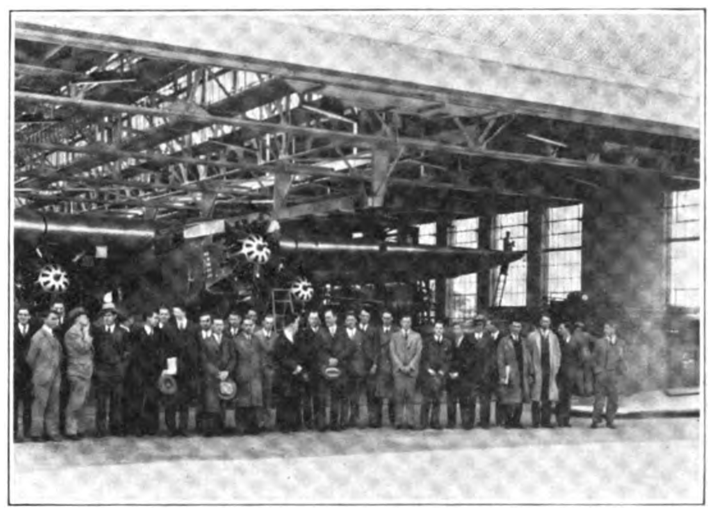

FIG. 2. *The Industrial and Mechanical divisions at the Ford Airport in Detroit.*

After the visit to the foundry we returned to the main plant to the cafeteria which was opened to us as guests of the company. That afternoon we visited the parts shop, the assembly plant, and the testing plant. We emerged from the testing plant nearly deafened by the roar of dozens of motors wide open. Wright Aero pleased us exceedingly in every respect and we are grateful to the company for a most valuable visit with them. In the Wright organization at the plant are several Sheff engineers and former students of Mr. Seward.

From Paterson we proceeded to the Edison Lamp Works and Lighting Institute of the General Electric Company at Harrison, New Jersey, where we again met the Electrical group, who had earlier visited the Engineering Societies Building and the Brooklyn Edison Company. At the Lamp Works is established a laboratory for the study of light, especially the field of illumination. A trained group of men experiment in what we found to be a very varied and mobile medium. Developments in the more common forms of lighting are made, as well as many in such specialized branches of work as aviation, lighthouse beacons, surgical apparatus and so forth. A clever demonstration of city lighting

was given for our benefit, including many of the schemes now run on the taller buildings in New York.

That night, Thursday, the group split up, the Electrical Engineers going to Niagara Falls, and the Industrial and Mechanical Engineers going to Philadelphia, with headquarters at the Penn Athletic Club. The trip to Philadelphia was very pleasant because of the courtesy and interest of the officials of the Pennsylvania Railroad, among whom are a number of Yale graduates, notably Mr. Atterbury, president of the railroad.

Friday morning we visited the Hardwick and McGee Carpet Mills. One of the most interesting features of this plant is its location which is almost better than ideal as far as shipping facility is concerned. It has contact with over half a dozen railroads, truck lines and waterways.

From here we paid a brief visit to the Philadelphia High Pressure Pumping Station, which supplies high pressure water to all the fire plugs in the city. We then boarded buses for the Sears Roebuck Company plant where we had luncheon. Each group was seated at an individual table with a representative of the company, a plan which gave us an excellent opportunity to become acquainted. That afternoon we inspected the plant. The most impressive feature of the Sears Roebuck is their marvelously developed system. Considering the thousands of orders shipped every day in the short time allowed, the results seem scarcely possible.

Friday night we embarked on another Pennsylvania train for Pittsburgh, which we reached in time for breakfast and a special train to the Carnegie Steel Company.

Our first stop was at the Homestead Rolling Mills, the largest rolling mills in the world. We saw the open hearth furnaces where the steel is made, and the tipping and pouring of the molten metal into the huge crucibles from which it is formed into ingots and thence conveyed to the rolling mills. The most impressive sight in the rolling mills was the control of the giant rolls and billets and driving engines by two men in a cab above the rolls by means of remote control switches.

From the Rolling Mills we boarded our special train for South Duquesne for a visit to the blast furnaces of the Carnegie Company. Later we went by our special train to Clariton, to see the coke plant of the Carnegie Company. This is by far the largest by-product coke plant in the world, charging 30,000 tons per day. The works are two miles long and a quarter of a mile wide, bordering on a river from which the coal is supplied by barges.

Our special train brought us back to Pittsburgh by 5:15 P. M., leaving us free from that time until Monday morning.

Monday morning we boarded our special train for the Universal. Portland Cement Company, where we investigated the process of making Portland Cement from slag and limestone. Our reception at the Universal was a joy to all of us for we were made very welcome by everyone. Our guides were interested in us and in their company. Previous to our visit through the plant we were provided with hats and shop dust coats to protect our clothing from the dust of the mill. The appearance of the plant is excellent, with perfecty kept grounds, lawns, and buildings, as well as attractive gardens and shrubbery. We left Universal with the highest regard for the plant and its personnel and grateful to all who had helped to make our visit so enjoyable and valuable.

We spent the afternoon in a visit to the Westinghouse Electric and Manufacturing Company. We were very much impressed by the mammoth size of the castings and parts. A 50-ton crane in this plant handled only the "toys."

After our inspection we were allowed to clean up a bit and were then ushered upstairs to dinner as guests of E. M. Herr, a graduate of the Sheffield Scientific School, president of Westinghouse. After dinner there were several interesting addresses by executives of the company, and finally an exhibition of several of the latest developments in the research department. Mr. Herr gave us a very enjoyable dinner and the company made our visit very interesting. That night we boarded a train for Detroit.

Tuesday morning we visited the Cadillac Motor Company. We had an extensive tour of the shops and assembly rooms, and later met the famous Eddie Rickenbacker. We were guests of the Cadillac Company at luncheon at the plant, after which we made our departure by bus to the Ford Motor Company.

The afternoon visit at the Ford Motor Company took us through the rolling mills of the plant and on to the body works. We repeated our visit the next day. The mammoth size of the River Rouge plant of the Ford Company almost beggars description. Cleanliness and order was an outstanding feature of every department we visited with the possible exception of the foundry. Luncheon at the company executive dining room completed a most enjoyable visit.

Immediately after lunch Professor Seward gave a brief message thanking us for our cooperation and wishing us a pleasant vacation. Those of us who were taking the early train east were excused and left by bus for the Statler to check out and get our baggage for our departure. The remainder of the group visited Ford Airport that afternoon.

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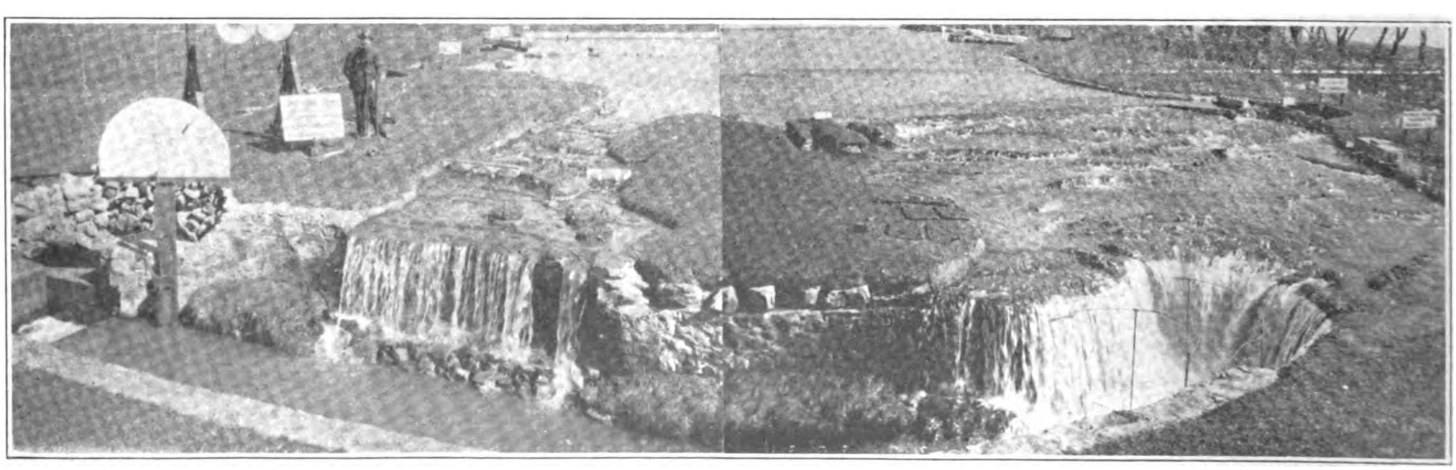

FIG. 3. *Model of Niagara Falls to show the effects of water diversion. Note the wearing away of the Horseshoe since 1760.*

A New Course Offered to Sheff Students

A Course in Applied Economic Science, with a Basis of the Physical Sciences, to be Offered in the Scientific School Next Fall.

By Dean Charles H. Warren

THERE has been during recent years a large and growing demand on the part of a very considerable number of students entering Yale for subjects of instruction centering about those phases of economic science which are fully and widely recognized as of great importance in their application to the problems of modern business. This demand undoubtedly reflects the well known fact that something like one-half of all graduates of the undergraduate schools follow business or commercial careers after leaving college. It also reflects the fact that in employing college graduates, those in charge of banking, investment, or other business enterprises, have in recent years been increasingly insistent on a thorough knowledge of economic principles and of methods of scientific analysis as applied to the problems of finance and business generally.

The Scientific School has always offered courses of study designed primarily to give a student a sound education in the fundamental principles and concepts of the natural and physical sciences and mathematics as a basis for professional careers in either pure or applied science, and particularly in engineering. Fully believing that the application of economic principles to practical affairs must be, if successful, an essentially scientific proposition and that a career in the modern world of business should properly be regarded as a professional career for which a positive and definite training is highly desirable, it has seemed to the Faculty of this School that it might appropriately offer, under the direction of those members of its staff whose field is economic science, a course of study quite definitely majoring in this field. This has been done. The new course has been approved by the Corporation and will be opened to students for the first time next fall. Although requiring only basic courses in the natural and physical sciences, and hence departing in this respect from our other courses, it, nevertheless, is quite in keeping with their general spirit in being distinctly scientific in character, and, like the other courses, has in view a definite professional aim.

While the new course may, and doubtless will, in time, result in the introduction of certain new subjects of instruction and in a general strengthening of the staff in economic science, the present program is really only a definite grouping, or organization, for the first time, under the heading of a single course of study, of individual subjects of instruction offered in the University in this particular phase of economics.

The description of the course as it appears in the catalog is as follows:—

Applied Economic Science.

This course has been arranged so as to offer a liberal and well-balanced program of studies in the natural and physical sciences, mathematics, and the modern humanities, including modern languages, and also to provide an opportunity for the student to devote particular attention during the upper two years of his course to those aspects of economic science dealing particularly with principles which are of fundamental importance in their application to business and commercial practice.

With the first three years of the course as a background, the Senior years offers a choice between three groups of subjects each representing a special phase of economic science, particularly accounting, finance, transportation, public utilities, and business forecasting. Adequate elective privileges are provided in the schedule as a whole so that the student may elect subjects of a cultural or more purely disciplinary type, and thus still further shape his course of study to conform to his individual needs and interests.

The conduct of the course is under the immediate direction of Mr. A. L. Bishop, who may be consulted for further information regarding the course.

Sophomore Year.

Division Officers: Mr. A. L. Bishop, Mr. McDonough.

FIRST AND SECOND TERMS.

Phys. 10 and 13a, b, 4 hrs.; Econ. 10, Elementary Economics, 3 hrs.; Econ. 11, Elementary Statistics, 3 hrs.; Anth. 11, Social Evolution, 3 hrs.; Modern Language, 3 hrs.

Junior Year.

FIRST AND SECOND TERMS.

Econ. 60a and 62b, Principles of Accounting, 3 hrs.; Econ. 52a, Distributing Systems, 3 hrs.; Econ. 21a, Corporation Finance, 3 hrs.; Applied Physiol. 63a, Industrial Physiology, 3 hrs.; Econ. 70b, Business Law, 3 hrs.; Engl. 21 or Elective, 3 hrs.; Elective, 3 hrs.

Senior Year.

FIRST AND SECOND TERMS.

Twelve credit hours for the year from one of the following groups:

(a) Accounting and Finance, (b) Transportation, Commerce, and Public Utilities, (c) Statistics and Business Forecasting; *and* Industrial Organization, 3 hrs. (first term); Personnel Problems, 3 hrs.; a course in a Science, Engineering, or Economics, 6 hrs.; Electives to make a minimum of 30 credit hours for the year.

SUBJECTS THAT MAY BE ELECTED IN SENIOR YEAR.

(a) *Accounting and Finance:* Econ. 46a, Problems of Taxation, 3 hrs.; Econ. 47b, Financial History of the United States, 3 hrs.; Econ. 54a, Banking, 3 hrs.; Econ. 55b, Advanced Banking, 3 hrs.; Econ. 58b, Business and Financial Forecasting, 3 hrs.; Econ. 65a, Cost Accounting, 3 hrs.; Econ. 66b, Advanced Accounting, 3 hrs.; Econ. 68b, Insurance, 3 hrs.; Econ.—, Economics of Investment, 3 hrs.; Math. 28a, Mathematics of Investment, 3 hrs.

(b) *Transportation, Commerce, and Public Utilities:* Econ. 20a, Natural Resources, 3 hrs.; Econ. 42a, Foreign Trade, 3 hrs.; Econ. 44b, Commercial Policy, 3 hrs.; Econ. 48b, Public Utilities

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The 1929 Mechanical Engineering Exhibit

Seniors Present Entertaining and Instructive Demonstration in Mason Laboratory

BY A. S. BOURN, 1930S

THE biennial exhibition given by the Yale Student Branch of the American Society of Mechanical Engineers was held this year on Friday and Saturday evenings, March fifteenth and sixteenth at the Mason Laboratory. Its purpose, in the words of the program, was "to furnish an opportunity to the local branch of the American Society of Mechanical Engineers, the students of Yale University, and the general public to visit the Mason Laboratory, study our methods of testing, become more familiar with some of the more recent developments in this branch of the engineering field, and, above all, to create a feeling of good fellowship between our guests and those who are giving the exhibit." The men in charge of the exhibition were F. P. Pendleton, '29 S., President of the Yale Branch; E. R. Anderson, '30 S., Vice-President; Edward Easton, '29 S., Secretary, and Prof. S. W. Dudley, Honorary Chairman.

Upon entering the main floor of the Mason Laboratory the visitor was confronted with a bewildering array of apparatus and a veritable Bedlam of noise. Following the crowd, he perhaps drifted over to where a 1929 Franklin Sedan was being tested on the chassis dynamometer. Upon inquiring what it was all about, he was informed that the Franklin was undergoing a test to determine its fuel consumption and horsepower at various speeds. The speedometer was also being checked, and the exhaust gases analyzed. The next exhibit which caught his eye was the Chrysler Imperial "80" engine with the stroboscope operating on its vibration dampener. The operator who was demonstrating the stroboscope tried manfully to explain just why the wheel seemed to stand still when the light from the stroboscope shone on it, but—well, it was terribly noisy just then. While the visitor was still looking at the Chrysler, the operator of the Diesel engine started his machine, thus drowning out all attempts at conversation. The visitor was told that the Diesel was not in the best of form just then or it wouldn't knock like that. After watching the Diesel for a few minutes, the visitor wandered along down the main floor reading the names on various pieces of apparatus—"General Electric Turbo-generator," "Sullivan Air Compressor," "Terry Steam Turbine." Seeing a crowd around some piece of machinery, he looked closer and found that the object of interest was a *Hornet* 9-cylinder radial air cooled airplane engine, exhibited through the courtesy of the Pratt and Whitney Aircraft Co. of Hartford. The engine was not set up to run but the visitor heard some of the main features of the engine explained and saw some parts from a similar engine. The Skinner Uniflow Engine was the next attraction to catch the visitor's eye. By the operator of this engine he was told how the principle of having the intake valves at the end of the cylinder and the exhaust ports in the middle cuts down the heat losses by making the steam flow in only one direction. At the front end of the Laboratory, the visitor found two long tables covered with a most intriguing array of machine part models—cam motions, linkages, worm gears, pulleys, and many others.

Picture taken from the west end of the Mason Laboratory, in which are located the turbines, generators, and testing machines described in the accompanying article.

After finally tearing himself away from those models, the visitor climbed the stairs to the second floor. Here the main objects of interest consisted of a moving picture called "The Thirtieth Part of a Hair" which was run off twice each evening in the lecture room, and the Westinghouse Air Brake. The moving picture, which was obtained through the courtesy of Norton and Company of Worcester, concerned the extreme accuracy and precision of modern machine tool manufacture. The visitor was shown how the air brakes worked and was told that the installation in the Mason Laboratory was the exact replica of those in use on passenger freight cars, and locomotives. Other exhibits on the second floor included a radiator test to determine the relative efficiencies of different types of house radiators and various tests on air flow.

On the third floor, the visitor found Prof. Lichty's apparatus for the study of detonation in internal combustion engines. He saw diagrams made by this machine showing the extreme pressure rise which occurs with detonation. The Fuel Testing Laboratory where the heating value and the volatile content of various fuels was determined was seen next. After convincing himself that there was no more to be seen on the third floor, the visitor returned to the second where he rested his legs while watching Norton and Company make a precision grinder.

The Yale Branch of the American Society of Mechanical Engineers feels that the exhibition was very successful in every way. The attendance was large and the interest shown demonstrates that the public wants to know the latest methods of machine testing. It is hoped that in the future the exhibition may be made a yearly affair instead of occurring every other year as it has in the past.

The Scientist Gazes Through the Crystal

Analysis of the Crystal Structure of Solids is Opening New Fields of Knowledge to the Physicist.

By Professor L. W. McKeehan

ALL of us, I suppose, can remember our earliest active interest in crystals.* These delectable crystals were kept in sugar-bowls for the most part, although rock-candy was still a possibility. Later on we began to dream of more lasting crystals, set in gold or platinum, given in moments of enthusiasm and paid for, if at all, only by months of toil. Those of us who have progressed even farther along the usual course

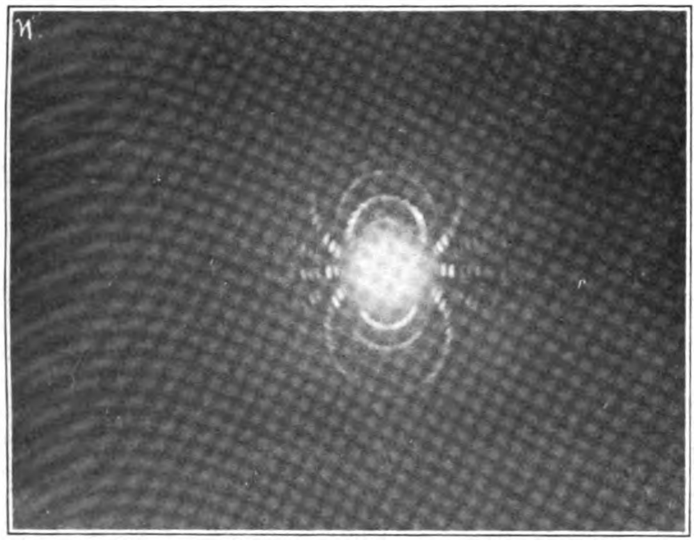

FIG. 1. *Diffraction pattern due to a single small crystal of manganese platinocyanide hydrate. Fourfold axis of crystal set vertical. Photographs taken on a plate. X-rays from a tungsten target covering a wide range of wave-length. This so-called laue photograph determines the angles between atomic planes in the crystal and therefore the shape of the unit, which in this case is a tetragonal prism with size much greater in length than its height. Variations in intensity between spots at the same distance from the center give information regarding the distribution of atoms in the unit.*

of events are especially concerned this winter in crystals of still a third sort which we hoard in lamentably over-sized coal bins. Even the big butter-and-egg men from the west who, according to tradition, warm themselves only at the fires of love, must depend for half of their stock-in-trade upon the preservative effect of salt crystals. If we believe everything we hear, we must expect, when ghosts, to gather about every crystal sphere held by a member in good standing of the clairvoyants' union.

* I omit reference to talcum powder and other less obvious crystals which surrounded our infancy.

Besides these ways, so nearly universal, in which crystals arouse our interest, there are some less noble matters in which we look to (or through) them for enlightenment. Here we must

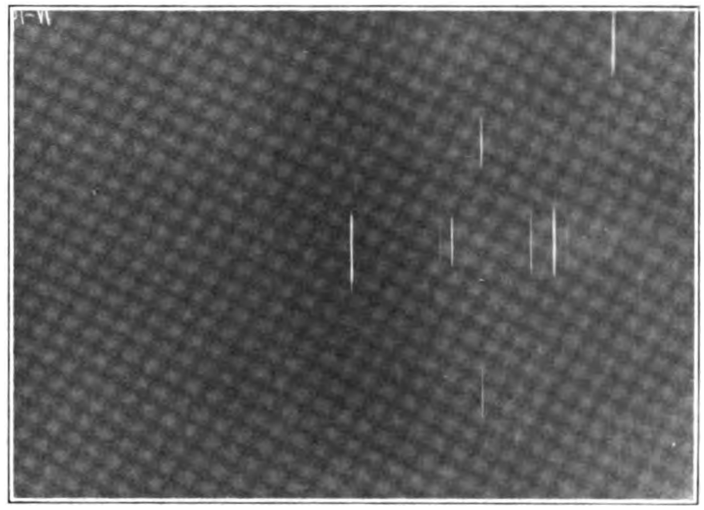

FIG. 2. *Diffraction pattern due to same sort of crystal as in Fig. 1, but in this case rotated about the tetragonal axis. This crystal gives the row of faint lines just below the center of the picture. The strong lines just above this row and many other strong lines on the plate are due to a crystal of calcium carbonate treated in the same way for comparison. Molybdenum x-rays were used, the beam passing through narrow slits before striking the crystal. The photograph was taken on a plate. It determines the exact dimensions of the unit whose shape is determined by Fig. 1.*

descend from psychic and psychological questions to more easily spelled, and less thrilling, physical questions. In making the descent we notice at once a great decrease in the number of people who are deeply interested and a great increase in the complexity of the questions. From here on it becomes harder to justify the title under which this is written; but let me try, nevertheless.

A favorite way for pedants to give an illusion of clearness is to clutter the paths of their discourses with definitions. An example will show the absurdity of the scheme in this case. I quote from the Standard Dictionary:

"crystal, *n.* I. *Chem. & Mineral.* (1) The solid mathematical form included under plane surfaces, systematically arranged, and connected by angles of fixed and definite value, which a chemically

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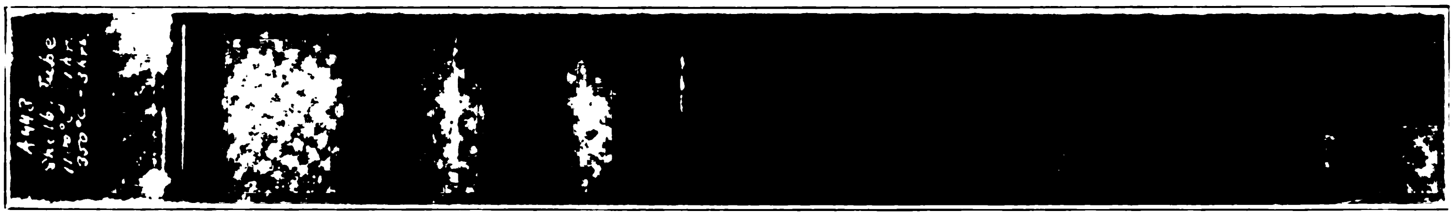

FIG. 3. *Steel tube ¼ inch outside diameter annealed at 1000°C. for one hour and reheated to 350°C. for three hours. Molybdenum target in x-ray tube. Lines are due to characteristic x-rays of wave-lengths about 0.712 and 0.708 x 10^{-8} cm.*

Progress of the Work on the Brontosaurus

The Restoration of this Great Dinosaur, First of its Kind Ever Discovered, Now Made Possible in New Peabody Museum

By Dr. Malcolm Rutherford Thorpe

The skeleton of *Brontosaurus excelsus* Marsh, now being mounted in the Peabody Museum of Natural History, is the first specimen of this genus of dinosaurs ever to be discovered. It is nearly a complete skeleton and was collected in 1879 by William H. Reed, four miles east of Lake Como in southern Wyoming, in strata of Morrison (Cretaceous) age. The remains as found were nearly in the position in which they were left at the time of death of the animal. This animal was of great size, some sixty-five feet in length and standing about fourteen feet high at the hips. In relation to body size it had a very small head, the neck was long, the back comparatively short, and the tail long. It has been estimated that the weight of the beast in the flesh was somewhere around 37 tons, or about one-half that of a modern whale of approximately equal length.

These animals show a remarkable specialization in the development of the skeleton to support so great a weight. The legs are pillar-like, the bones solid, long and straight with rugose ends, indicating a large amount of cartilage at the articulations. The vertebrae, in contrast, are marvelously light in construction, but of exceeding great strength. These various elements of the skeleton point to an amphibious habitat where luxuriant and nutritious aquatic plants grew in great abundance. Such an habitat now may be found in tropical America in the region of the lower Amazon, with its sluggish bayous and numerous islands supporting a dense tropical vegetation. Living in conditions of this nature, these huge beasts were comparatively safe from their enemies, the carnivorous dinosaurs which also lived at that time, and the water eased the weight of their great bodies.

It is now just fifty years since Professor Othniel C. Marsh published the first notice of the finding of this specimen. Since that date it has been freed from its rock matrix, most of the missing parts restored, and a fairly complete description of all of the bones has been published. In addition to Professor Marsh who published several reports on the skeleton and who had an active interest in its development up to the time of his death in 1899, several other men who have since become well-known figures in the scientific world worked on the cleaning and studying of the bones, as for instance Erwin H. Barbour, now Professor of Geology in the University of Nebraska, State Geologist and Curator at the State Museum; Adam Herrmann, later, after leaving Yale, for many years Chief Preparator at the American Museum of Natural History in New York; S. W. Williston, who became Professor of Paleontology in the University of Chicago; George Bauer, later one of the leading scientists of Europe; R. S. Lull, Director of the Peabody Museum and Professor of Paleontology in Yale; T. A. Bostwick, who completed fifty and one-half years in the service of this Museum; Dr. R. W. Westbrook, another of the former Museum men; and last, but not least, Hugh Gibb, Chief Preparator, who has rounded out more than forty-seven years of service in this Museum and who is now in charge of the mounting of the entire skeleton.

Throughout these fifty years the bones, for the most part, have been in storage, although the hind legs and the hip girdle were mounted in the former Museum building, on the corner of High and Elm Street, by Mr. Gibb under the direction of Professor Beecher. With somewhat more exhibition space and a building constructed to carry great loads, we are now able to mount the entire skeleton. This work is being carried on in the Preparation Room. A scaffold was built on which have been placed in proper position the vertebrae from the end of the hip region to the beginning of the neck. The height above the floor is about fourteen feet, that required to place the leg bones in their proper posture. This means that all of the mid-section of the body between neck and tail will be completely restored where minor parts are missing, all of the iron work made which will be necessary to carry the weight of this central section weighing close to three tons, and the final mounting done in the Preparation Room. After this is completed it will be moved in sections to the first floor, the scaffold will be unbolted, taken down

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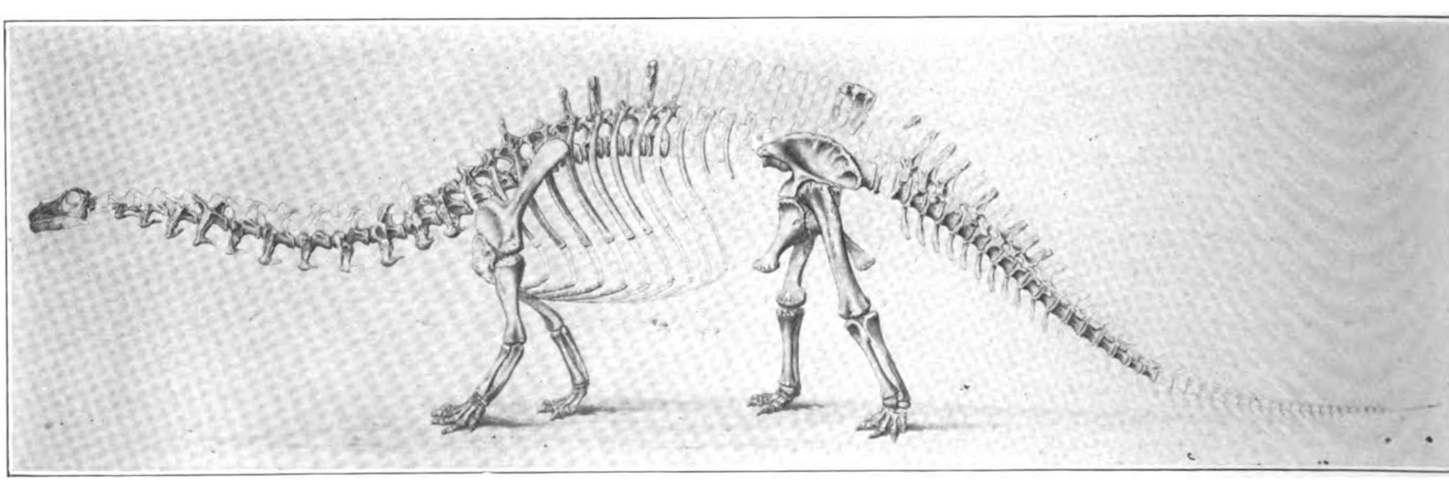


Fig. 1. *A view of the vertebrae of the Brontosaurus as restored.*

Photography at the School of Medicine

A Description of the Rapid Advancement Being Made in Photography as an Aid to Medicine

By Luther Simjian

MANY visitors to the New Yale School of Medicine laboratories at Cedar Street and Congress Avenue are surprised to come upon a complete photographic establishment occupying a suite of nine rooms in a building where they expect to find only facilities for chemical, bacteriological and pathological investigations.

Even though such an arrangement is unusual in medical schools, it is logical that provision should be made for an expert and expeditious photographic service at the call of every department requiring pictures for teaching, publication or research purposes. As photography has progressed it has become more and more useful in medicine. At best, an exact description of a growth or a lesion can only be approximated in words. If this

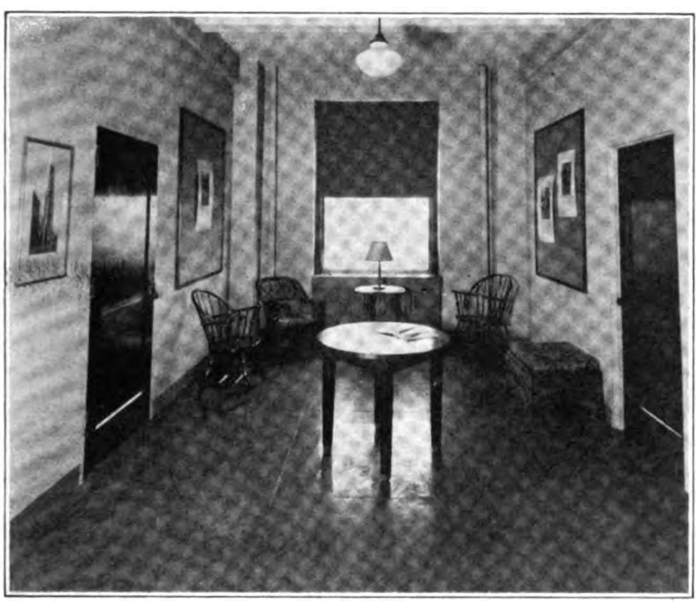


Fig. 1. *The Waiting Room.*

description is supplemented by a fairly taken photograph, the record becomes more accurate and more useful to others and to the investigator himself. In fact, in the photograph, which can be examined at leisure, it is often possible to discover matters which could with difficulty be ascertained from the specimen itself.

The value of photography in teaching is again obvious. It is a means of preserving for the student interesting cases which would otherwise be available to only a small group. The course of a curative or disease process can be vividly recorded and studied over and over. It is also possible to photograph and throw upon a screen microscopic sections which could otherwise only be examined by one student at a time through a microscope.

One of the principal uses of photography in medicine is the making of illustrations for scientific articles which are to be published. Most of these are made more concise and clear by the use of pictures. Since knowledge of medical progress is diffused largely through the publication of facts gained through research, it is evident that photography plays here a role of great importance.

Although the Yale School of Medicine is relatively small, having a maximum enrollment of 200 students, the photographic division during the past calendar year made 3,000 negatives, 5,000 prints and 2,000 slides. It can be assumed that this amount of work represents the minimum requirements of the School, for each department must pay from its own budget for the photographic service rendered and would therefore guard against needless making of pictures.

With such a volume of photographic work to be done, it was natural that the School should seek to have it performed by personnel skilled in this particular kind of work and prepared to do it quickly and economically. It was therefore decided in 1922 to centralize the photographic service for the entire School, just as all the routine laboratory work has been centralized. Previous to that time several of the departments each had a staff photographer, and other departments had none, and only makeshift facilities were provided for development and printing of plates. The decision was then made to employ one photographer,

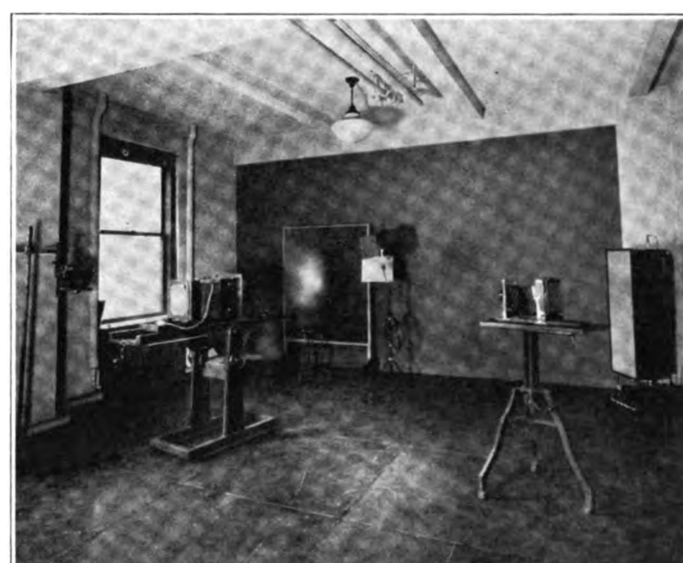


Fig. 2. *The Main Studio.*

with such assistants as he might need, and to give him space and equipment for every type of photography needed by the School, within convenient reach of all departments. The principle was established that the section should be non-profitmaking but self-supporting, and that each piece of work should be paid for by the department ordering it.

Accordingly, when the new laboratories were built last year, a suite was set aside for photography on the ground floor. The main entrance to the suite introduces one to a waiting room hung with portraits and New England scenes, the taking of which is the hobby of the writer, who has had charge of the photographic

section of the medical school since it was organized. These pictures help to put the patient at his ease and to illustrate the point that a scientific and artistic interest may well be merged.

The main studio, at the right of the waiting room, is well supplied with daylight and with the necessary equipment for creating intense actinic light values at night and in dull weather. Into this room are brought all patients who must be photographed, except those from the contagious ward. Here successive pictures may be taken of a skin eruption, for instance, to show the progressive stages resulting from a particular kind of treatment. Through a flexible lighting system, and lenses of different focal lengths, it is possible to obtain photographically in this studio almost any effect desired.

To the left of the waiting room is the private office of the department, and beyond that the room for photomicrography. The machine here is equipped with a combination of lenses capable of magnifying to visible proportions a colony of germs in a minute drop of a liquid. A set of Grade A filters is employed in photographing colored sections. To obtain an intense and steady illumination a carbon arc lamp is used. The apparatus rests on a solid support which will not be sensible to external vibrations, for the slightest movement would cause misrepresentation of the object being photographed.

The photomicrography-developing room adjoins the room where the photomicrographic objects are photographed. In order to keep this room in constant darkness a double door is employed which makes it possible to enter or leave the room without letting in any light. Gross (non-microscopic) photography is done in another room, equipped with a mercury vapor lighting system. Specimens are placed in distilled water while being photographed, in order to avoid the glare which might result when taking a wet object. In this room x-ray pictures are reduced to convenient sizes and lantern slides are prepared for mounting. The autochrome process, whereby the natural colors of an object are preserved in the photograph is used when it is desirable to record colors.

The dark room for general purposes contains an autofocus enlarging machine. By means of a pedal operated by slight pressure, an intense light is thrown on the negative for the desired length of time. It is possible here to enlarge a picture greatly without losing any of its distinctive features. The printing room contains a modern large-sized printing machine having a surface opening for negatives up to 11 x 14 inches. This instrument is also operated by a pedal which leaves the hands free to handle any number of negatives. A washing machine is provided to give the prints a thorough cleansing and removal of acids.

The general work room is furnished with a dry mounting apparatus, several sets of trimmers, and a filing system which makes it possible to find quickly any negative or print wanted.

While the photographic division is concerned primarily with the needs of the medical school, its facilities are such that it can serve other schools and departments of the University, as well as other institutions requiring photography which is not conveniently obtainable elsewhere.

FIG. 3. *Photomicrography Room.*

Thus far the photographic section has operated on its income, experiencing some years a slight deficit and other years a slight profit. The amount of work has more than doubled in five years, showing the growing uses for photography in teaching and research. A service has been provided which is not available anywhere in the commercial world, which makes it possible to obtain photography at the moment it is needed, to get the exact results desired, and to obtain at small cost and small effort the required number of prints or slides. It may be truly said that the photographic section is an important cog in the activities of the medical school and hospital, and that it has pointed the way for a similar organization in other medical schools.

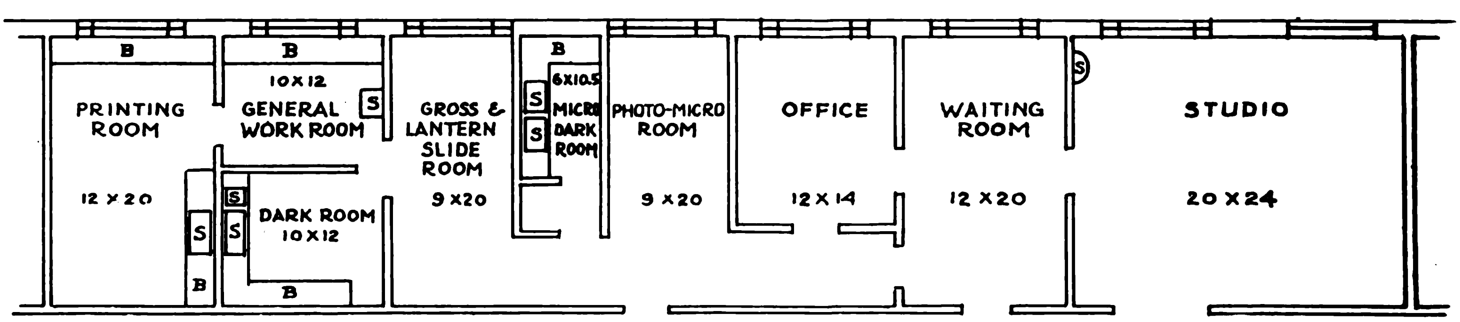


FIG. 4. *Floor Plan of the Photography Department.*

General Principles of Sound Recording

Each stage in the development of methods for recording sounds has introduced serious problems for the engineer

By Dr. Edward C. Wente

THAT sound is perceived by the ear as the result of a disturbance in the air was known to the ancient Greeks, and that objects are set in vibration by intense sounds must have been observed by primitive man, but it was not until 1857, or less than a century ago, that the first instrument was constructed for making a graphical record of sound waves. In that year Leon Scott patented in France an instrument (Figure 1) which he called the phonautograph. A piece of smoked paper was attached to the cylindrical surface of a drum, so mounted that when rotated by hand it moved forward at the same time. A stylus was attached to the center of a diaphragm through a system of levers in such a manner that it moved laterally along the surface of the cylinder when the diaphragm vibrated. Over the diaphragm was placed a barrel-shaped mouthpiece. When

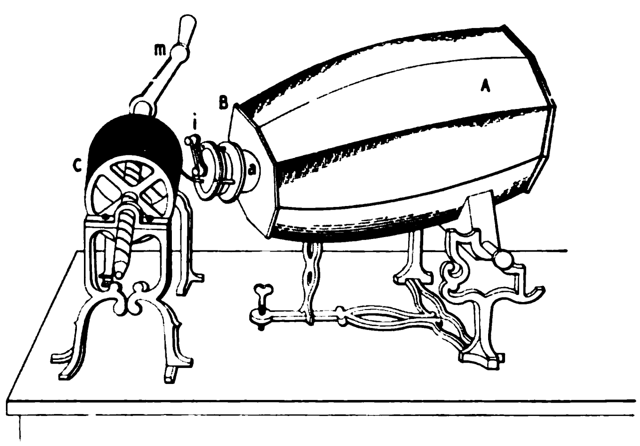


FIG. 1. *Sound was first recorded on the phonautograph of Léon Scott.*

the drum was rotated, words spoken into the mouthpiece caused the stylus to trace a wavy line upon the smoked paper. This wavy line was the first known record of sound vibrations.

It was twenty years later, in 1877, that Edison brought out an epoch-making invention. He constructed a machine very similar to the phonautograph but differing in two important details. The smoked paper was replaced by a sheet of tinfoil, and the stylus was attached directly to the diaphragm so that it traced an impression of variable depth, as the diaphragm vibrated, instead of a wavy line as with the phonautograph. After such a record had been made the drum was returned to the starting point and, with the stylus in place, again rotated as before. The recorded sound was then intelligibly reproduced. Thus Edison gave us the first phonograph.

Improvements in the Phonograph.

In subsequent models the tinfoil was replaced by a wax cylinder. For many years the wax record, either in cylinder or disc form, was used almost exclusively for the recording and reproducing of sound. Although many other methods of recording have been suggested, it is only in the last few years that records made photographically have come into the commercial field as competitors. At the present time both the wax and the photographic records are used in conjunction with motion pictures.

Photographic records are now being made by many different types of apparatus, but they may be divided into two general classes. In one of these, the record is a trace of constant photographic density but of variable width, while in the other the width is constant but the density varies. In one or two proposed methods the record is a combination of both types.

Almost all systems experimented with today have at least one element in common with the phonautograph: a diaphragm that is set in vibration by the sound to be recorded. The diaphragm may be mechanically connected to the engraving mechanism or recorder as in the phonautograph, or, it may be electrically connected as in most modern systems. In practically all systems the diaphragm forms an essential element.

Unfortunately a diaphragm does not in general have the same response at all frequencies. A favorite experiment in lectures on elementary physics is to sound a tuning fork and with it, through the air, set in vibration a second tuning fork. In this experiment it is important that the pitch, or the resonant frequency, of the two forks be very nearly the same, or the motion set up in the second fork will be too small to be observable. Diaphragms, and in fact almost any other type of mechanical system, will have at least one resonant frequency, which means that, under the action of sound waves, the response will be much greater at this frequency than at any other.

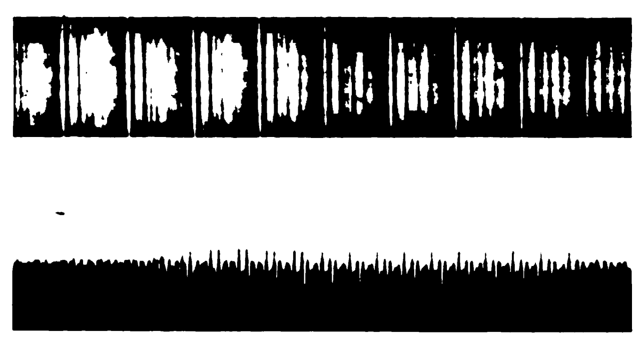


FIG. 2. *Photographic records of sound may be either of constant width and varying density, shown above, or of constant density and varying width, shown below.*

Poor Quality of Reproduction.

In the older methods of recording resonance was purposely introduced in order to obtain records of sufficient amplitude. The frequencies lying in the resonance region were then much over-emphasized. The sound reproduced from such records had a blasting and metallic quality, and well deserved the title "canned music."

(Continued on Page 31)

The Simplification of Highway Traffic

A Book Report of Mr. W. P. Eno's Latest Work on the Traffic Problem

By C. J. Tilden

THE publication on May 1st of Mr. William Phelps Eno's fifth book* on the regulation of highway traffic brings to mind his long continued and persistent effort in this field of civic endeavor. It was in 1899 that he made the first constructive suggestion for improving traffic conditions on the streets of New York City. Two years later he published a proposed set of regulations, asking for suggestions and criticism from those who were interested. In due time these were sent to the Board of Aldermen of the greater City of New York, with the suggestion that they be put into effect. These gentlemen, however, declined to adopt them, wishing to substitute another set which had been compiled by a member of the Board. The police, on the other hand, favored Mr. Eno's proposed regulations but felt in doubt as to the extent of police authority to handle matters of this kind.

With characteristic thoroughness Mr. Eno then took up a study of the charter under which the various elements of the greater City function, and found that not only did the police have the authority to regulate traffic on the city streets but that in Section 315 of the City Charter they were specifically instructed to do so. This situation was brought to the attention of the Police Commissioner, General Francis V. Greene, together with the regulations which had been revised and improved and printed in the form of a four-page folder entitled "Rules for Driving". Commissioner Greene adopted these at once, and issued them as a general police order. This was on October 30, 1903. The "Rules for Driving" have formed the basis of practically all municipal regulations issued since that time.

The task of keeping these regulations up to date, receiving and considering the suggestions and criticisms that have come from others and endeavoring to get the thought of the best minds in the country to work on improving them is but one of many to which Mr. Eno has devoted time, personal effort and means for over twenty-five years. Five revisions and new editions were made prior to 1918. In 1919 the Highway Transport Committee of the Council of National Defence, of which Mr. Eno was a member, took over the responsibility of revision and again brought out a new edition of the regulations. Out of this Committee grew the Highway Education Board and in 1922 this Board requested the Eno Foundation for Highway Traffic Regulation, Inc., to continue the work of the Council's Committee "for the investigation, codification, publication and standardization of general highway traffic regulations". The latest edition (October 30, 1928) of these regulations, now known as the C.N.D. (Council of National Defense) Code of General Highway Traffic Police Regulations, is printed in the book and is also issued in the form of a six-page folder, conveniently arranged for standardization and adoption by any city or town. It comprises twenty-one definitions and eight articles or chapters with forty-six sections and a final page of fifteen "safety rules for pedestrians." The portion relating to vehicles provides fully for the regulation of passing, turning (including the left-hand turn), stopping, following, backing, right of way and signals, and also the control and treatment of horses. The safety rules for pedestrians are excellent and complete. If it were only possible to educate all users of city streets in these regulations there would be not only a great saving of life and lessening of injuries, but traffic would flow more smoothly.

William Phelps Eno, Yale '82.

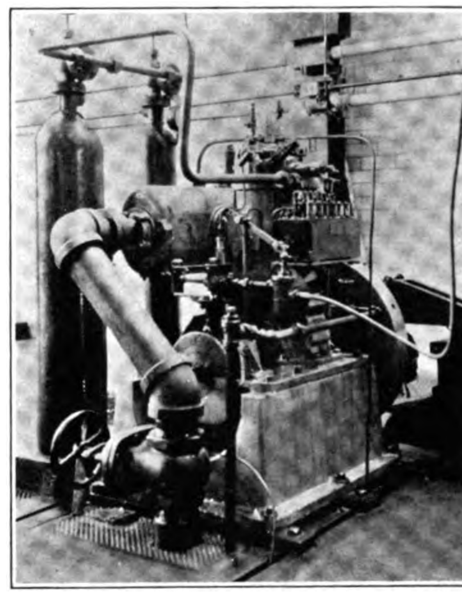
The Eno Foundation for Highway Traffic Regulation, Inc., was established by Mr. Eno in 1922, "in order that my work may be carried on more effectually during my lifetime and in perpetuity". Its activities are controlled by a self-perpetuating board of twenty-one directors. It has been generously endowed by the founder so that very substantial resources will be available to continue the work of education and investigation, to which Mr. Eno has devoted so much of his time and means.

The new book, "Simplification of Highway Traffic," is a volume of upwards of two hundred pages with many illustrations. Some of it is a revision of his previous books, but

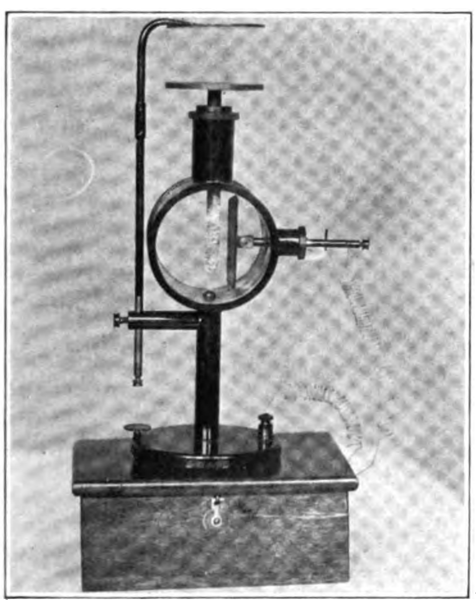
(*Continued on Page 33*)

*Simplification of Highway Traffic, by William Phelps Eno, Yale '82. Published by The Eno Foundation for Highway Traffic Regulation, Inc., Washington, D. C., 1929. 201+xi pp. with index. 74 illustrations.

ABOVE.—*An architect's drawing of the Fort Lee Bridge which will connect New York and New Jersey. The center span of 3,500 feet makes it by far the longest suspension bridge in the world. This span is almost twice as long as that of the well-known Philadelphia-Camden bridge.*



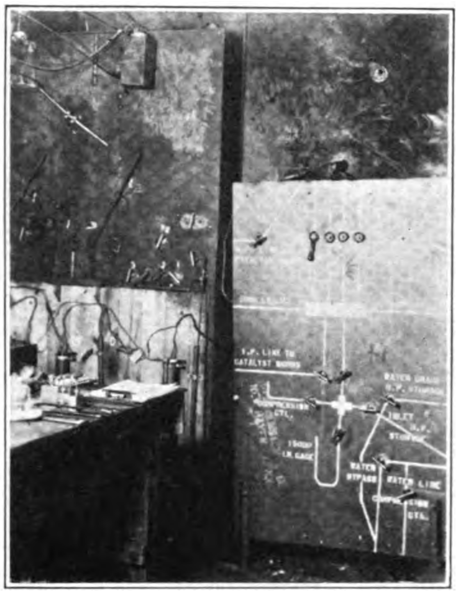
BELOW.—*This Zeleny Oscillating Leaf Electroscope in the Sterling Physics Laboratory is used for measurements in the study of radioactivity and of other ionization effects in gases.*

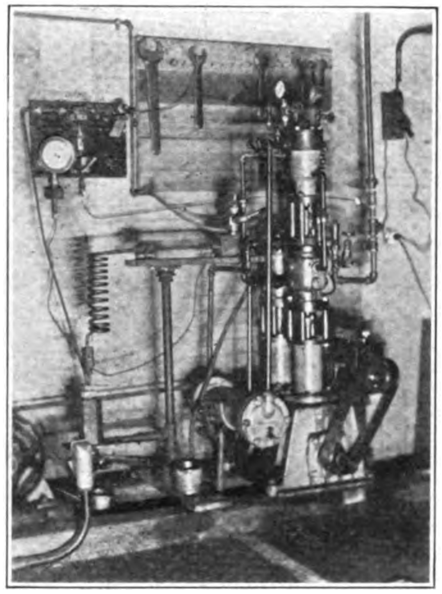


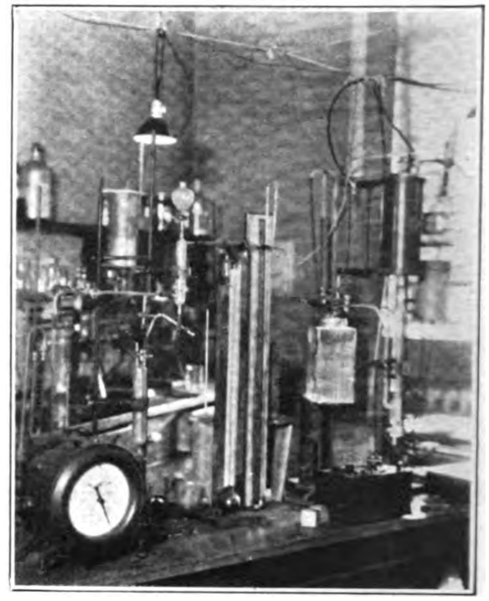
ABOVE.—*A Mianus 7½ horsepower Diesel engine recently installed in the Mason Mechanical Engineering Laboratory, where it is used for efficiency tests by students.*

CENTER ABOVE.—*The method of erecting the main towers, which rise to a height of 284 feet above the water is shown here. The channel clearance is 135 feet. This is the Bristol tower of this bridge.*

BELOW—*The Mount Hope Bridge connecting Bristol with Portsmouth, Rhode Island. This will be the longest suspension bridge in New England, its center span being 1,200 feet in length. Including its approaches, the whole bridge is 5,000 feet long.*



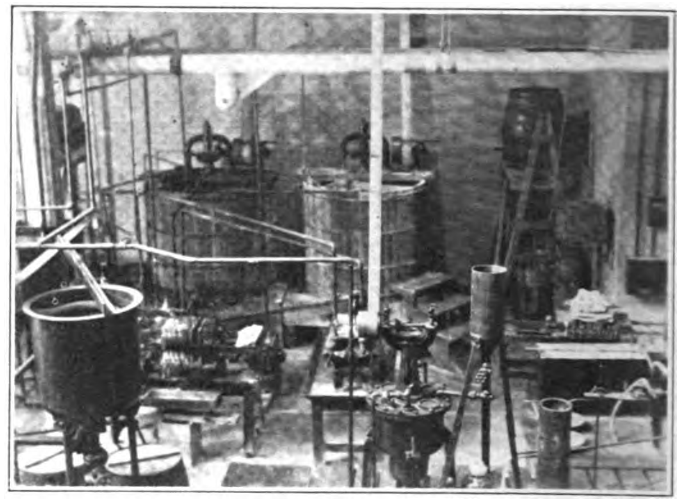




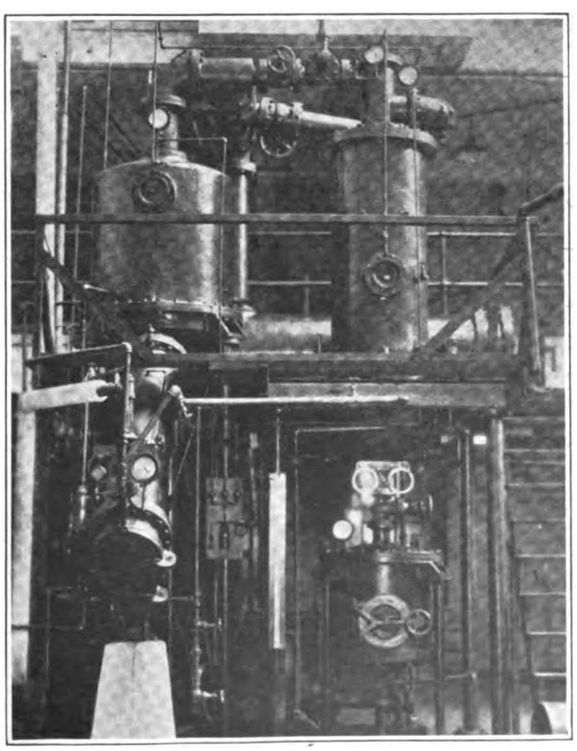
Left Above.—*Control board of apparatus in the Sterling Chemistry Laboratory for the study of gas reactions at high temperatures and pressures. Methyl alcohol is now being produced by catalytic methods from carbon monoxide and hydrogen. The steel barricades shown are for protection from the high pressures employed.*

Center Above.—*This Rix three-stage compressor is designed to operate at a pressure of 4,500 pounds per square inch. With the aid of an auxiliary hydraulic pump, gas pressures of 15,000 pounds per square inch are obtained.*

Right Above.—*With this apparatus a study is being made of catalysts for the decomposition of methyl alcohol. It has been found that the results obtained with this apparatus are comparable with those obtained with the reverse reaction, the synthesis of the methanol.*

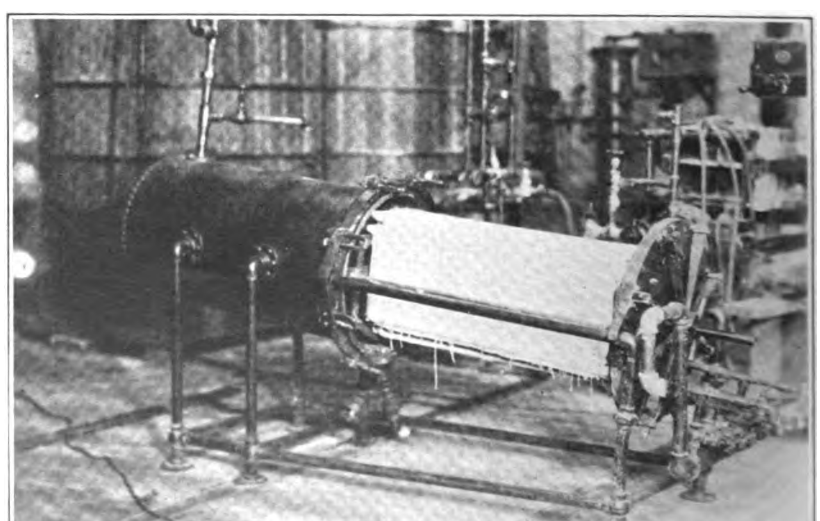


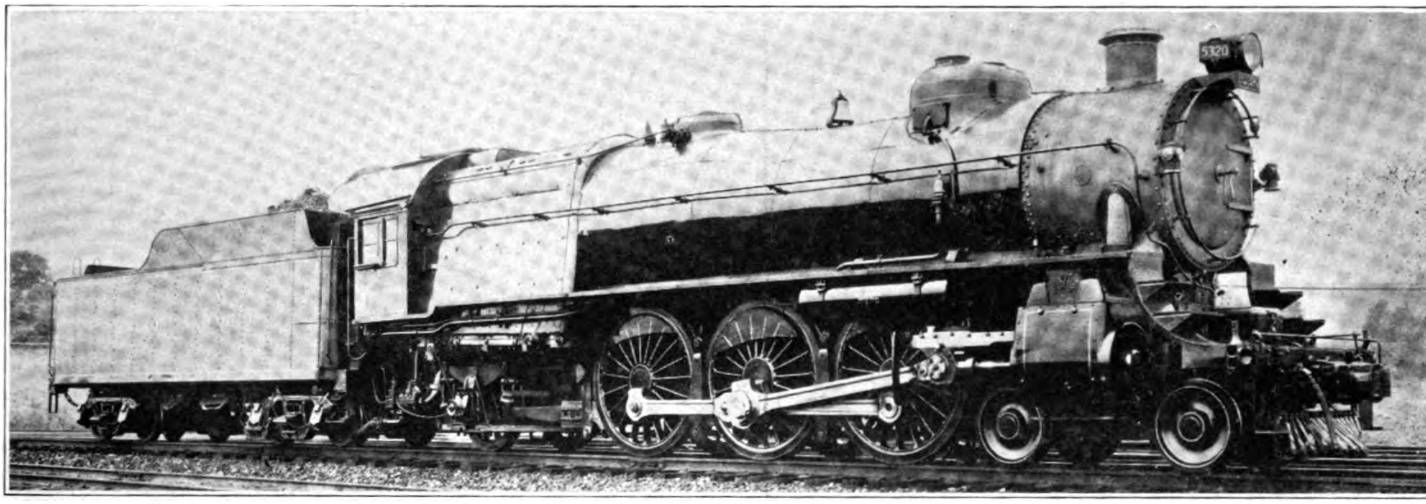
Below.—*A double-effect evaporator. This is so arranged that solid materials may be removed as they separate out of the solution evaporated.*



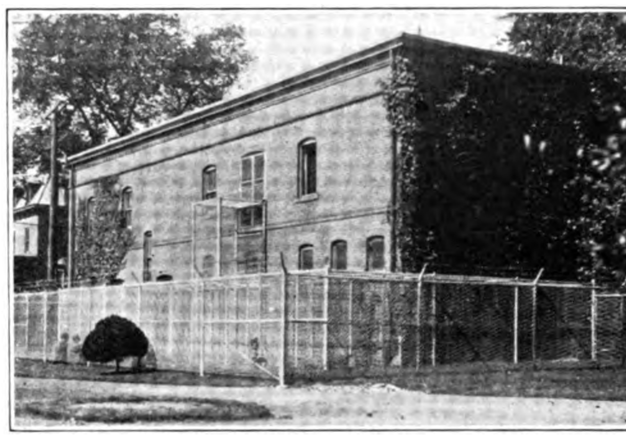
Above.—*A view of a part of the equipment used in the study of commercial filters by Chemical Engineering students.*

Below.—*This Kelly type filter is especially suitable for the filtration under pressure of liquids containing a considerable amount of solid matter in suspension. It is shown in position to be cleared of filtrate.*

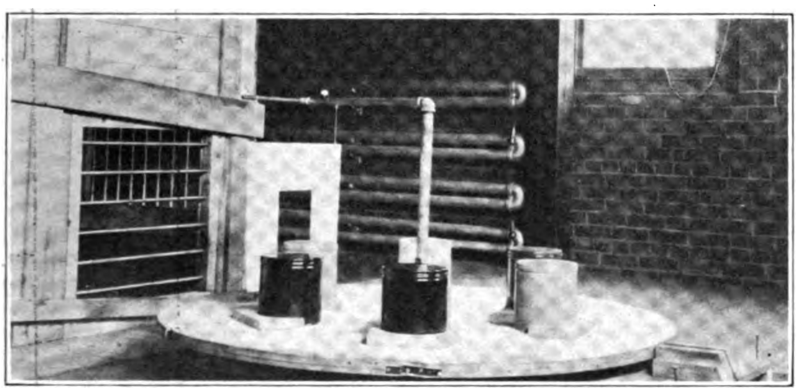




ABOVE.—*A Pacific type passenger locomotive on the Baltimore and Ohio Railroad equipped with a Caprotti valve gear installed by the Baldwin Locomotive Works. The usual outside valve gear and piston valves are replaced by balanced poppet valves, of which there are two inlet and two exhaust valves per cylinder, operated by gear-driven cams. Fuel savings of over ten per cent have been made on road tests. This gear was developed and first used on the Italian State Railways.*

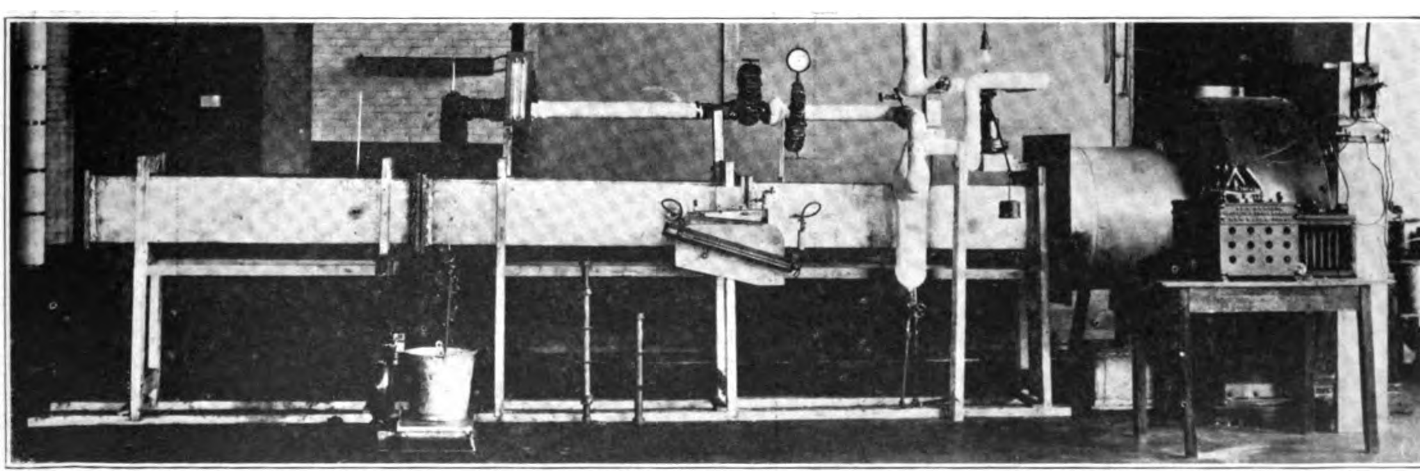


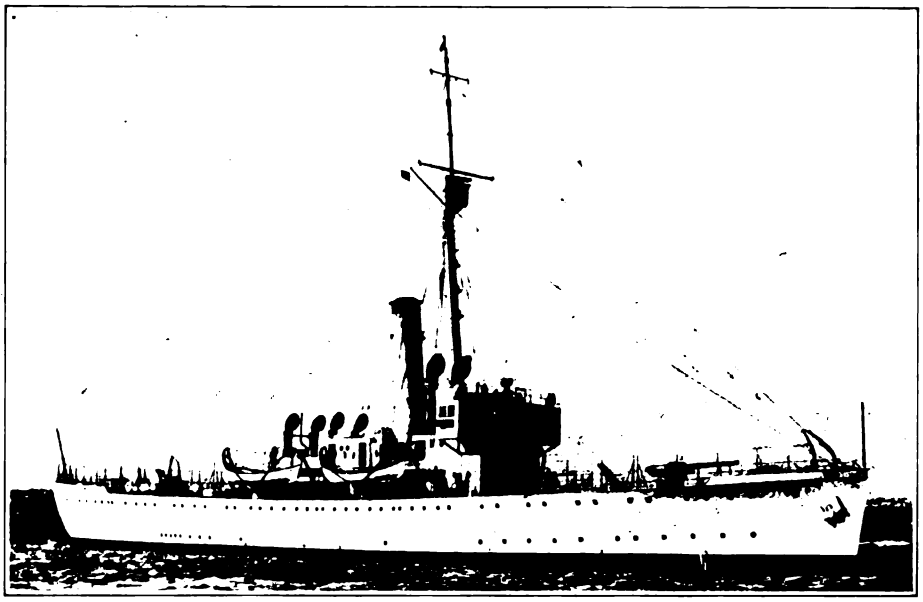
ABOVE.—*The Yale Primate Laboratory on Prospect Street. In this laboratory, chimpanzees and rhesus monkeys are being used in the study of various psychobiological problems.*

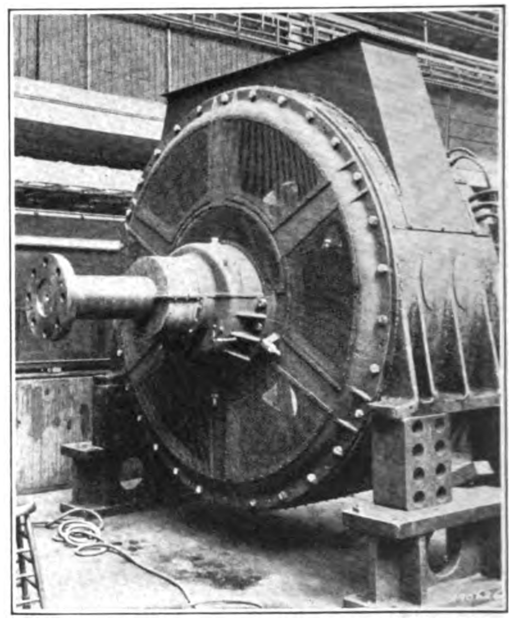


LEFT.—*View of an apparatus which is now being used in this laboratory in a study of the characteristics of memory of the chimpanzee.*

BELOW.—*An extended surface heater on which research work is being done in the Mason Laboratory of Mechanical Engineering. These heaters consist of a steam tube with radial fins of some non-ferrous metal of high heat conductivity, being designed to transmit a large quantity of heat in a short time for a minimum expenditure on constituent parts.*

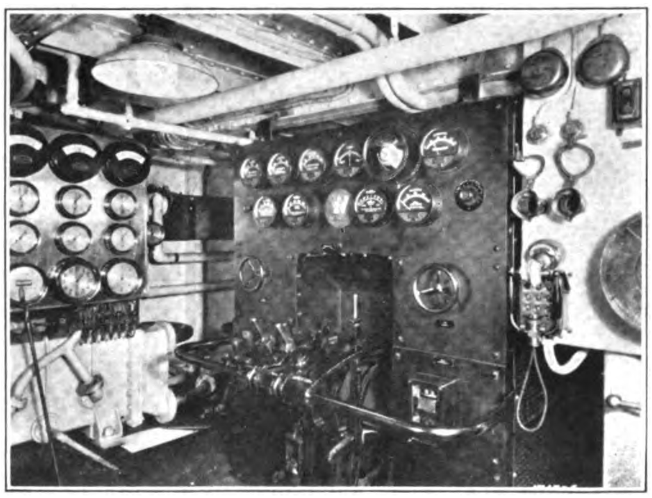






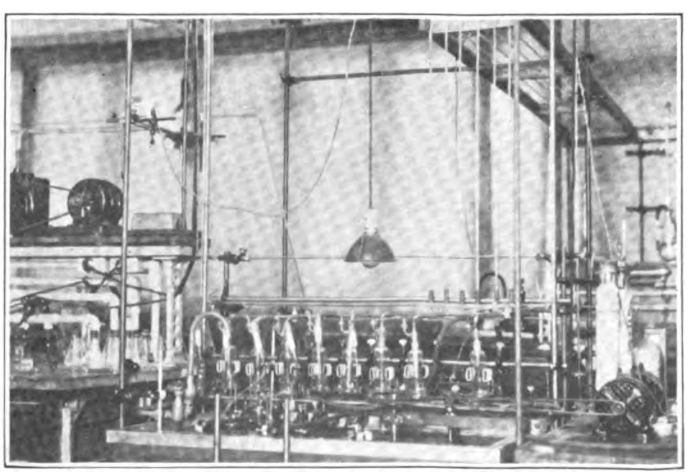
LEFT ABOVE.—*The U. S. Coast Guard Cutter Tahoe, one of the five new electric drive cutters just delivered to the Coast Guard for off-shore service such as the iceberg patrol and the Alaskan waters patrol. Recently a party of marine engineering students under Professor Seward of the Mechanical Engineering Department made a trip from New London to New Haven on this ship.*

RIGHT ABOVE.—*The 3,000 horsepower drive motor which gives the cutter a speed of 17 knots at 163 revolutions per minute. This motor is supplied with current by a turbo-generator.*

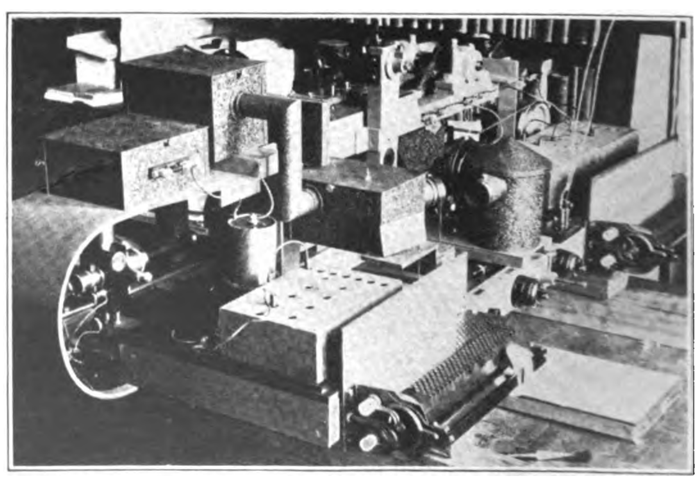


LEFT.—*Main controls or "throttle board". Rapid maneuvering ability and full backing power as well as high economy are outstanding characteristics of this, the most modern type of marine engineering equipment. One of the most fruitful sources of economy with this equipment is the use of electric power for all auxiliary power requirements, such as steering engines and hoists.*

BELOW.—*Apparatus now being employed in the study of the thermodynamics of electrolytic solutions. These experiments are being conducted by the physical chemists in the Sterling Chemical Laboratory.*



BELOW.—*A Koch-Goos Microphotometer used for measurements of the complex natures and the relative intensities of the spectral lines on spectrograms.*

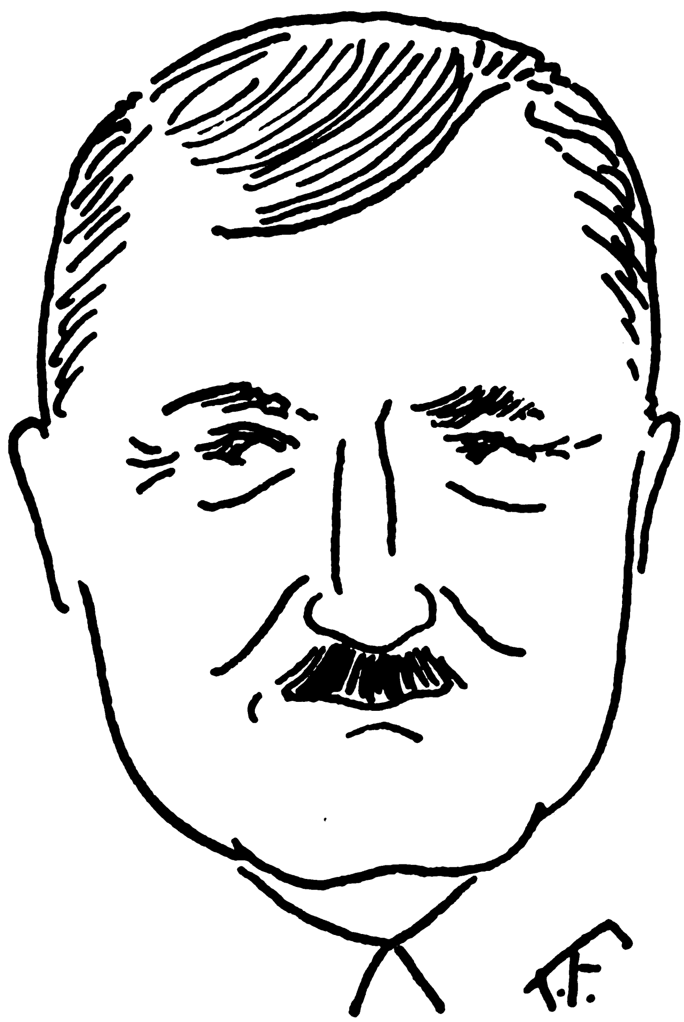


P·E·R·S·O·N·A·L·I·T·I·E·S

No. 9 *HARRY ALFRED CURTIS*

AS I opened my office door one morning, not so many weeks ago, the following note on the desk caught my eye: "4 A. M. Am just leaving for home. Please ask etc., etc." No need to look for the signature—who else but Dr. Curtis would work on to such an hour, forgetful of the passage of time, determined to finish an appointed task. The ability to drive ahead and do the thing that needs to be done and do it quietly, efficiently, and without ostentation, is one of his outstanding characteristics.

Harry Alfred Curtis was born February 16, 1884, in a log cabin on a cattle ranch, thirty miles south of Denver, in the foothills of the Rockies. At the age of eight he entered grammar school at Littleton, Colorado. At fourteen, while still in grammar school, his interest in chemistry was first aroused, through contact with a neighbor's boy who had recently moved from the east. The two boys started a laboratory in the wood shed and all their spare time, after the many chores that fall to the lot of a country boy, was spent in scientific pursuits. Apparatus was not plentiful in that country nor was there much money available for its purchase. Considerable resourcefulness was called for to meet this lack and many a household utensil mysteriously disappeared from the kitchen, to appear later in the wood shed laboratory as a beaker or a test tube! As the experimenting continued, its scope broadened to include things electrical and mechanical as well as chemical—the nice distinctions among the sciences to which we are accustomed being of little consequence to these youthful scientists.



His grammar schooling being concluded at the age of sixteen, the family moved to Vancouver for the brief period of eight months and then returned to Colorado. While there, young Curtis learned the plumber's trade. This seemingly unimportant fact is mentioned here because of the glimpse it gives into one of the sources of that wealth of practical information that so frequently astonishes his co-workers. He entered high school upon his return to Colorado, but lack of funds forced him to leave after a year. To earn money to return he taught for a year in a country school, meanwhile continuing his high school studies, even to the extent of riding on horseback to the high school once a week to recite to the principal and thus gain credit for his work. By dint of hard work the four year course was completed in only two years of attendance. Further acquaintance with chemistry was made in that last year of high school. Having a sympathetic teacher, he was not subjected to the regular routine but was allowed to browse as much as he pleased in the laboratory, his interest in chemistry being thereby greatly stimulated.

In the summer following completion of the high school course, various conversations with an uncle who was studying Mining Engineering at that time aroused in him a great desire to go to college. His mechanical turn of mind, joined to his interest in chemistry, made it natural for him to wish to apply his chemistry in industry. Though completely without funds and knowing that little help could be expected from home, he nevertheless decided to go to college and study chemical engineering. He entered the College of Engineering of the University of Colorado in the fall of 1904. With the aid of a small scholarship that paid his tuition and by working outside of school hours, he was just able to make ends meet during his first year.

Toward the end of this year an unfortunate illness plunged him into debt and to pay it off he entered on his first business venture. He took a contract to dig fifteen miles of telephone pole holes for a local line between two farms! This seems rather a strenuous means of recuperating from a serious illness but it allowed him to enter on his second year of college with a clean slate. The financial problem was less troublesome in succeeding college years. A job as stockroom clerk the second year and laboratory assistant the next year paid all expenses, and by his senior year his resourcefulness in earning money had developed sufficiently to enable him to devote more time to various extra-curricular activities and interests. We might mention among these a certain young lady, Irene Hall, who was a senior in the college of Liberal Arts, who later became Mrs. Curtis. The way in which Curtis was regarded by his fellow students is well shown by the fact that he was elected president of the combined senior class of the university.

Curtis' professional career started in the summer following his junior year at college, when he did miscellaneous chemical and assaying work for a gold extraction mill. He had many

(Continued on Page 38)

Astronomy

Dr. Earnest W. Brown, Sterling Professor of Mathematics, was elected President of the American Astronomical Society, at the last annual meeting of the Society. Dr. Brown has also served as President of the American Mathematical Society. The late Professor Simon Newcomb is the only other mathematician and astronomer who has occupied both these Presidencies.

The Bruce Medal of the Astronomical Society of the Pacific for 1929 has been awarded to Dr. Frank Schlesinger, Director of the Observatory. This award is made, usually every year, on recommendation of the Directors of six great Observatories in this country and abroad. A special meeting of the Society was called on the evening of April 12 for the purpose of presenting the medal to Dr. Schlesinger, who then delivered an address on "Some Pioneer Observers."

Dr. Harold L. Alden, in charge of the Yale Telescope at Johannesburg, has just published a paper in the Astronomical Journal giving the distances of fifty stars in the southern hemisphere. This is the first product of this kind from the Yale Telescope. Dr. Alden and his assistant are now securing plates in sufficient number to determine accurately the distances of about 200 stars every year, a number about equal to those secured at all the five or six northern observatories engaged in similar work. It is therefore to be expected that our knowledge of the southern skies in this respect will soon be on a par with the northern. The plates and results are of excellent quality and more than come up to expectations.

Civil Engineering

As the time is fast approaching when the members of our graduating classes will seek employment, the opportunities presented by the various fields have a particular significance. So many loose statements are constantly being made in regard to the comparative size of our various industries that it is interesting to hear directly from the Department of Commerce.

Under date of April 1, 1929, Mr. George N. Thompson, Secretary of the building code committee, writes that:

"I am informed that construction regarded as a single industry, as distinguished from groups of industries such

(Continued on Page 30)

Physics

At a meeting of the American Physical Society held in Washington on April 18 to 20, the following papers from the Physics Department were read:

1. "Wave-Length Measurements of Gamma Rays from Radium and its Products" by Mr. Luville T. Steadman.
2. "Basis for Computing the Age of a Mineral" by Professor A. F. Kovarik.
3. "The Optical Constants of Solid Mercury" by Mr. Roland S. Baldwin.
4. "Interpretation of Deviations from Ohm's Law on Fermi Statistics" by Mr. Henry Margenau.
5. "Solution of Problems in Quatam Mechanics by Operator Analysis" by Mr. R. B. Lindsay and Mr. R. J. Seeger.
6. "Some Critical Points in a Study of Recent Quantam Theories" by Mr. R. J. Seeger.

Mining and Metallurgy

On April 28th Professor Phillips delivered the annual Non-ferrous Lecture before the New Haven Section of the American Society for Steel Treating. The subject of the lecture was "Directional Properties in Wrought Metals."

Prior to the Easter Recess a party of students in Metallurgy made an inspection trip to the various copper and lead smelting and refining plants of the New York vicinity. An afternoon was devoted to an inspection of the Atha Works of the Crucible Steel Company, in addition to the following non-ferrous plants:

Balbach Plant, United States Metals Refining Company, Newark.

Raritan Copper Works, Perth Amboy.

American Smelting and Refining Company, Maurer, New Jersey.

Nicholls Copper Company, Laurel Hill, Brooklyn.

Geology

Professor Carl O. Dunbar will spend the summer with the State Geological Survey of Nebraska continuing the study of the forma of the coal measures in Nebraska and adjacent states.

During the summer, Mr. Everett Lees, a graduate student in Geology, will lead a surveying party of the Canadian

(Continued on Page 30)

Mechanical Engineering

Professor H. L. Seward has been selected by the Society of Naval Architects and Marine Engineers to write their contribution to the World Engineering Congress to be held in Tokyo, Japan, in October, 1929. The paper will be entitled, "Marine Engineering and Design."

The class in Marine Engineering will embark on a destroyer early in May for visits of inspection to the U. S. Torpedo Station, Newport, R. I., U. S. Submarine Base, New London, Conn., and the Brooklyn Navy Yard.

Professor H. L. Seward is Acting Chairman of the U. S. Shipping Board Fuel Conservation Committee during the absence from this country of Captain C. A. MacAllister, USCG, and Captain R. D. Gatewood, USN.

On March 29 and 30 Professor S. W. Dudley attended a joint meeting of the Council of the American Society of Mechanical Engineers, representatives of the Professional Divisions, and Standing Committees at Princeton University, as a guest of Doctor A. M. Greene, Dean of Engineering. The meeting was held in the Engineering Building at Princeton which afforded a very convenient and attractive meeting place. Arrangements for the coming meetings of the Society, including the Fiftieth Anniversary Celebration of the American Society of Mechanical Engineers, to be held next April in Washington, were discussed.

Botany

The Department of Botany was well represented at the Christmas meetings of the Botanical Society of America held in New York. Nearly all the staff and graduate students were in attendance, and papers were read by Prof. G. E. Nichols, Dr. G. R. Wieland and Mr. A. A. Dunlap. Prof. Nichols was reelected Treasurer of the Botanical Society.

Dr. G. P. Clinton, Dr. C. G. Deuber, and Mr. R. P. Marshall presented papers at the Fifth National Shade Tree Conference held at the Brooklyn Botanical Garden in February. Mr. Marshall was elected Secretary-Treasurer for the coming year.

Prof. G. E. Nichols has lectured recently before several of the Garden and Bird Clubs of the state. He is also serving as Chairman of the College Entrance Examination Board Committee on Botany.

Biology

Reconstruction of the top floor of the laboratory has been started. This makes available several rooms for investigation as well as store rooms for physical and other laboratory equipment.

During the last week in March, the meetings of the American Association of Anatomists were held at Rochester. The meetings were well attended and papers were presented by many former students of this laboratory, Drs. Hooker, Detwiler, Hoskins, Adams, Lucille Moore Burns, Greene, Zwemer, Copenhaver, R. K. Burns, Swett, Nicholas and Stone. Dr. Nicholas presented two papers and conducted a demonstration of movements in foetal rats.

Professor George Baitsell attended the meetings of the College Entrance Board during the Easter recess.

The activities of the laboratory have been intensified during the present season upon experimental embryological research.

Among the laboratory visitors of the past month were Professor Faure-Fremiet and Professor Gray.

Medicine

On February 13 the Yale Medical Society was addressed by Dr. Alfred F. Hess on the subject of Irradiated Ergosterol.

"Medieval Psychiatry" was the subject of a lecture delivered at the Psychiatry seminar, on January 30, by Dr. George W. Henry.

Under the auspices of the Connecticut Branch of the Society of American Bacteriologists, Dr. F. d'Herelle, on January 25, lectured upon the subject of Asiatic Cholera.

On Alumni Day, February 22, special exercises were held in the Sterling Hall of Medicine. The alumni who attended were addressed by Dr. William Herrick of Columbia, by Dean Robert M. Hutchins of the School of Law, by Dean M. C. Winternitz, and by President James R. Angell.

Dr. Herrick, the first speaker, paid a tribute to Dr. Thomas F. Smallman of Brooklyn, who was graduated in the class of 1905 M. Dr. Smallman by hard and conscientious work built up one of the largest private practices in greater New York. He has left the product of his life work to Yale, to be used in helping to solve the problems of the general practitioner.

On February 20, 1929, before the New Haven Medical Association, Dr. L. F. Wheatley and Dr. T. R. Russell of New Haven read papers on "Results to be Expected from the Therapeutic Use of X-Ray and Radium."

The New England Health Institute will meet in Hartford April 22-26. This promises to be New England's most important public health event for 1929. On Tuesday evening, April 23, a banquet will be held at the Hotel Bond, the speakers including Governor Trumbull, Dr. George E. Vincent, Dr. Hugh S. Cumming, Surgeon General of the United States Public Health Service, Dr. Edward K. Root, member of the Connecticut Public Health Council, and Professor C.-E. A. Winslow. The program for the week includes addresses by the most prominent men in public health work throughout the United States.

Forestry

The School of Forestry is contemplating the application of the Case System in the teaching of certain phases of forestry. To this end, a recent gift of $10,000 from Irving Bonbright and Sterling and Edward Childs, of New York City, will be spent in gathering and presenting data on selected forest tracts which will serve as cases. R. P. Holdsworth, '28, is at present gathering material on a forest in Sweden and Professor Hawley is at work preparing maps and a report on the Eli Whitney Forest, of the New Haven Water Co. The experience gained in preparing and using these two cases will be drawn upon in the further development of the system.

The spring field work for the Junior class will be held from May 23 to June 12, under the direction of Professor Hawley. The class will map, organize, and prepare a silvicultural plan of treatment for an area of approximately three thousand acres. The tract to be covered this year is part of the Eli Whitney Forest and lies about fifteen miles east of New Haven.

Dean Graves has returned from a five weeks' trip in the South, where he visited the more important experimental forests and research stations of the southern forest schools and of the Federal Forest Service. The trip was undertaken in connection with the work under the Charles Lathrop Pack Foundation, recently established by the gift of $200,000 to the Yale School of Forestry by Mr. Pack.

Professor Toumey will take up his residence on the Yale Demonstration and Research Forest at Keene, N. H., on June 15. He will be assisted in his work on the Forest this year by C. L. Stevens, '26, R. D. Stevens, '28, W. D. Miller, '30, T. W. Dahl, '29, and J. L. Deen, '29. Three of the men will be engaged in investigative work, the results of which will later be embodied in dissertations presented as partial requirements for the Ph.D. degree at Yale.

Dr. Toumey will sail on July 3 to attend the International Congress of Forest Research Stations, which convene in Stockholm the latter part of July. He plans to return, sailing from Oslo, on August 8 and will be at Keene again about August 20. Mr. C. L. Stevens will be in charge of the forest during Dr. Toumey's absence.

Professor Chapman has been elected President of the Connecticut State Commission on Forests and Wild Life, succeeding United States Senator F. C. Walcott. Mr. Chapman has been a member of the Commission since it was created in 1925, for the purpose of purchasing lands for State forests and for fish, game and park uses.

Professor Hawley gave a talk on "Forestation of Watersheds" before the Conference of Water Works Officials at Hartford, on April 22.

Professor Record spent the Easter recess at the Field Museum of Natural History in Chicago, in connection with his work there as Research Associate.

Electrical Engineering

During the Easter recess Professor A. E. Knowlton, assisted by Mr. Abbott, conducted a Short Course for Electric Metermen in Dunham Laboratory. This course has become almost an annual event because of the frequent requests by the Meter Committee of the National Electric Light Association, that the College offer such a course. There were in attendance twenty-seven meter specialists from various electric utility companies in Connecticut, Massachusetts, and New Hampshire. Members of the N. E. L. A. committee and technical representatives of the manufacturers of electric measuring instruments were also present.

Professor Turner delivered a lecture before the Radio Club of America, April 10, in New York City on "The Characteristics of Audio-Frequency Transformers as Modified by Design and Operating Conditions." This was a report on an experimental investigation of the effect upon the characteristics or response curve due to changing the amount of iron in the core, the ratio and actual

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GEOLOGY

(Continued from Page 28)

Geological Survey working in the upper Yukon region, British Columbia. A fellow student, Mr. J. W. Crickuray, will be engaged in similar geologic work for the Canadian Survey in northern Quebec. Mr. Charles Hunt has just received a release from his graduate studies to join a field party of the United States Geological Survey in the high plateau of Western Colorado for the summer.

Dr. Roland W. Brown leaves the geology department of Yale University in June to become the paleobotanist on the United States Geological Survey at Washington, D. C.

Professor Alan M. Bateman has obtained leave of absence which enables him to depart the first of May for Africa, in order to study the geology of the copper deposits of Katanga, Belgian Congo, and Northern Rhodesia, before attending the meetings and geological excursions of the International Geological Congress to be held in South Africa during July and August.

The members of the Department of Geology have completed a drastic revision of the Pusson and Schuchert Text Book of Geology, Part I, by L. V. Pusson. It will be published by John Wiley & Son, and will be ready for use in the fall.

L. Sunard, graduate student, is leaving for Northern Rhodesia after the college year to carry on geological work there.

Robert Le Clereq, an assistant in the Department of Geology, is leaving to engage in Geological work in East Africa.

Dr. Ellsworth Huntington has recently returned from a journey to South America. Three points stand out as of special interest: In the first place, unless one travels widely in South America, it is almost impossible to realize what rapid material progress has been made in recent years. The appearance of the cities is changing with extraordinary rapidity under the influence of the automobile, the movies, and other modern conveniences.

In the second place, the almost complete failure of the Indian population of the countries of the Andean Plateau, especially Ecuador, Peru, and Brazil, to share in this change is astonishing. Phlegmatic, submissive, and unprogressive, a quality of the Indian often ascribed to the combined factors of Spanish oppression, strong alcoholic drinks, and the use of the drug known as coca, Doctor Huntington believes that an additional and even more important factor is found in the fact that ever since the coming of the Spaniards, the most progressive, energetic and attractive Indians, both men and women, have largely been lost to the Indian community. In the early days the leading men were killed, and the finest women became the wives of the Spaniards. At the present time, the same process continues, except that capable Indians, whether men or women, tend to leave the Indian community, and intermarry with the halfbreeds or Cholas. Thus, as a rule, only the unprogressive and stupid remain in the pure Indian communities.

Doctor Huntington's third point of interest is the climate of the past. He was surprised to find to what a remarkable degree the conditions in the dry parts of Peru and Bolivia agree with those which he has previously seen in the dry parts of Asia, North America, and Australia. There seems to be overwhelming evidence that during the past few thousand years the climate at some periods has been distinctly moister than at present.

ELECTRICAL ENGINEERING

(Continued from Page 29)

number of turns in primary and secondary and their position with respect to the core; and the operating grid bias and plate voltages of the associated amplifying tube.

Professor Turner, who is a member of the Meetings and Papers Committee of the Institute of Radio Engineers is to present a paper on "Inductance as effected by the Initial Magnetic State, Air-Gap and Superposed Currents" at a joint meeting of the Institute of Radio Engineers and the American Section of the International Union of Scientific Radio Telegraphy at Washington May 13-15.

A Committee consisting of Prof. Turner, Mr. Koenig of the Electrical Testing Laboratory and Mr. Davidson of the Brooklyn Edison Company have been engaged during the past year planning a Symposium on "Shielding in Electrical Measurements" which will be held at the annual meeting of the American Institute of Electrical Engineers at Swampscott in June. This subject is becoming of vital importance to all who are concerned with precise measurements both in power and in communication.

Another lecture in the Electrical Engineering Graduate series was given April 16 on "Lighting of Airways and Airports" by Mr. H. E. Mahan of the Illuminating Engineering Laboratory of the General Electric Company, Schenectady. He has had considerable experience in the field of lighting for flying, having been detailed to assist the Naval experts in the lighting of the landing decks on the Navy's aeroplane carriers, "Saratoga" and "Lexington," as well as preliminary work on the "Langley."

He pointed out that adequate lighting is one of the three requirements which must be met in order that an airport may obtain the Class A rating of the Department of Commerce. The speaker outlined the problem of the beacons along the airway and the proper illumination of facilities at the intermediate landing fields. The subjects taken up in connection with the airport itself were those of the beacon, illuminated wind direction indicator, boundary lights, obstruction lights, hangar flood lights, ceiling projector and landing area systems. One or two striking developments were commented upon by the speaker; one of these was the employment of tungsten crystals within the incandescent lamp bulbs for the purpose of removing the dark deposit on the inside of the bulb as the lamp ages. Another was that extensive tests by the General Electric Company and the Bureau of Standards at Washington indicated definitely that Neon light had no greater ability to penetrate fog than white sources of light but that such advantage as had been attributed to Neon was due to its distinctive color rather than penetration.

The lecture was arranged in connection with the course in Illumination Engineering in the Electrical Engineering Department.

CIVIL ENGINEERING

(Continued from Page 28)

as agriculture and manufacturing, appears to be the largest in the country.

"In speaking of construction I do not mean simply buildings but also public works, public utilities and engineering projects which are commonly reported in the total figures. As you know, the total for the past year is given by various authorities as somewhere between seven and eight billion dollars. This represents the final value of the product."

Under date of March 27, 1929, Mr. Thomas S. Holden, Vice-President of the F. W. Dodge Corporation, estimates that the annual construction expenditures in the entire United States (averages for the past four years) are:—

"Total Building	$7,388,700.00
"Public Works and Utilities (mainly civil engineering)	1,252,900.00"

These figures are of value as showing the vast preponderance of building over all other classes of construction.

(Continued on Page 33)

GENERAL PRINCIPLES OF SOUND RECORDING

(Continued from Page 21)

Because of the complex nature of speech and music and of the great amount of distortion introduced by the early recorders and reproducers, the surprising thing is not that the quality of reproduction was poor, but that the reproduced sounds were at all intelligible. In fact it has been suggested that the invention of the telephone, which preceded the phonograph, might have been delayed for many years had the complex nature of speech sounds been generally known at the time, since its inventor probably would have dismissed his ideas as altogether impracticable.

Although considerable distortion may be introduced by the recording and reproducing systems before the character of the sounds is so changed that they can no longer be recognized, the amount of distortion must be kept extremely small, if all classes of sounds are to be reproduced to such a degree of fidelity that the ear cannot distinguish them from the original. It is necessary, therefore, to diminish the distortion by the diaphragm to a negligible value.

Electrical Recording.

The electrical method of recording, which is today widely used in the production of commercial sound records, has been developed primarily so that a diaphragm giving a uniform response may be used and at the same time a record of sufficient amplitude be obtained. In the modern method the pick-up diaphragm is made a component part of the recording microphone. Here a small amplitude of motion will serve, as the voltage generated may be amplified to an amount sufficient for operating a rugged and distortionless recorder. A comparison of the diaphragm in the Edison recorder with that of the microphone used in the majority of present recording systems is interesting. In the former the maximum amplitude required for the loudest sounds is about 0.001 inch, whereas in the latter under ordinary recording conditions it is only about one-tenth of this amount, and the weight of the microphone diaphragm is only one-twentieth as great as that of the Edison recorder. It can thus be seen how the problem of design of a pick-up diaphragm is greatly simplified in the electrical method.

It is important, of course, that the rest of the recording system shall also be free from distortion. If a microphone of uniform response is available, however, the design or a distortionless recorder is made comparatively easy, for its sensitivity may to a large extent be disregarded, as the required power can be obtained by vacuum-tube amplifiers. In the electrical method, extraordinary improvements have been made over the older systems in elimination of distortion.

The problem of developing recording apparatus is in many respects identical with that of developing high quality radio transmitters. With recording apparatus, however, there is the additional problem of distortion introduced by the record itself. If, for instance, a record is run at a speed of ten inches per second, and a tone having a frequency of 5,000 cycles per second is recorded, the length of one cycle on the record will cover a distance of only 0.002 inch. In the case of wax records the needle must have a very fine point; and in the photographic record the width of the light beam as measured along the direction of motion of the film must be extremely small. At whatever speed the record may be driven, there will always be some frequency beyond which all tones will become more and more attenuated. Although the loss of the higher frequencies does not impair the tone quality as much as does the presence of sharp resonance regions, yet it reduces the intelligibility of speech and the richness and brilliancy of musical sounds.

The Problem of Distortion.

There is another type of distortion commonly present in reproduced sound, which is frequently designated non-linear distortion. It is introduced when the response of any element of the system is not proportional to the stimulus. A pure tone, for example, of sine wave form, as shown in "a" of Figure 3, may be reproduced so as to have a wave form like that of "b". Distortion of the wave form in this manner is equivalent to the introduction of extraneous frequencies. If the magnitude of these

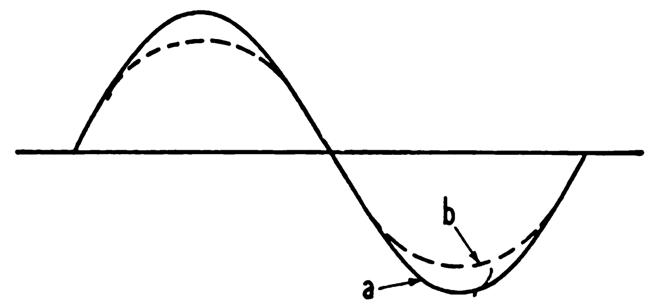

FIG. 3. *Non-linear distortion changes the shape of a sine wave form from "a" to the flatter top type of "b".*

added frequencies is too great, the tone quality will be very disagreeable. A small amount of distortion of this kind, however, is not noticeable, because the primary tone will mask the extraneous one. It is a well known fact that a tone must be much more intense to be heard if another, and particularly a lower, tone is sounded simultaneously.

A type of distortion peculiar to recording is that introduced by a non-uniform speed of the medium on which the record is being engraved. This may not always be serious, but in certain cases of sustained tones, speed variations cause a disagreeable flutter and in some types of music a decided harshness of tone.

One of the most serious problems with which the radio engineer has to contend is static interference. This also has its counterpart in sound reproduction from records. As the ether through which the radio waves are sent is non-homogeneous because of extraneous electrical disturbances, so the sound record is non-homogeneous on account of the non-uniformity of the material on which it is engraved. The noise resulting from these irregularities is often designated as surface noise. With the wax record, most of this noise has its origin in the minute irregularities of the material and with the photographic record, in the finite size of the grains forming the photograhpic image.

The difficulties of eliminating this noise arise from the fact that the physical intensity of audible sounds covers an exceedingly wide range. The ratio of pressures of the maximum to the minimum is about ten million. If a record of this extreme range of volume were to be recorded the amplitude of the loudest tone would have to be ten million times as great as for the faintest tone. There is a maximum amplitude that a record can accommodate, which in the case of the wax record is about 0.002 inch. If a tone having an intensity near the maximum level is recorded at this amplitude, the amplitude of a tone just audible would be only 0.000,000,000,2 inch. It is difficult to get a material having a degree of homogeneity corresponding to this value.

A similar condition exists with photographic records where the pattern is formed by grains in the emulsion which have a

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PROGRESS OF THE WORK ON THE BRONTOSAURUS

(*Continued from Page 18*)

and reerected where the skeleton will ultimately stand in the Great Hall, and the iron work of this mid-section simply bolted into place. Then the neck vertebrae with the skull and the tail

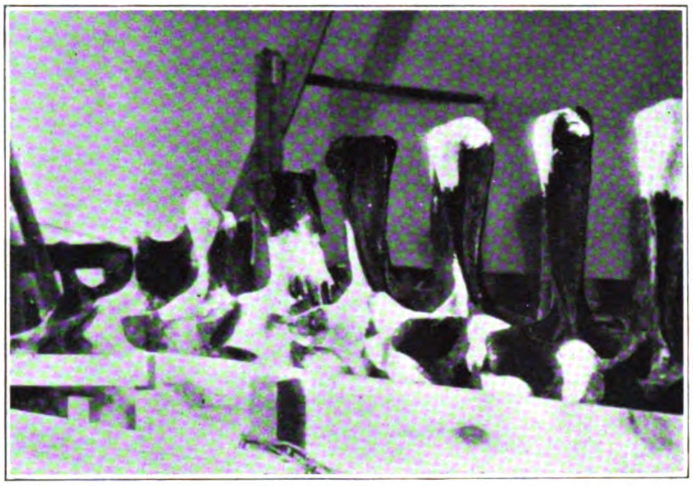


FIG. 2. *Another view of the vertebrae. The dark portions are the original fossil, and the white portions have been restored.*

elements will be erected. By this method the time necessary to complete the mount in the exhibition hall will be reduced to a minimum. In addition, the time saved will be very considerable in that we have all adequate equipment for this work in the Preparation Room, but if all of the mounting were done on the first floor we would have very few or no conveniences for handling such heavy bones and for making the iron braces to carry the great weight.

FIG. 3. *The skeleton of the great dinosaur as it will appear when the restoration is completed.*

If we consider the total cost of the time spent in studying these bones, the skilled labor necessary to clean them, the material used, the cost of the publications dealing with this skeleton, and all of the various items of expense which are inseparable from the mounting of this huge animal, it would be a fairly conservative estimate to say that it had cost thousands of dollars a year since its discovery. However, it is worth every cent of it. It is the type specimen of this genus and species of huge plant-feeding amphibious dinosaurs and the first one of its kind ever discovered.

SERVING THE HUMAN MACHINE

(*Continued from Page 10*)

The diseases and disabilities which are treated in the Orthopaedic division can be grouped under (a) Bone and Joint conditions resulting from injuries, i. e., fractures and sprains; (b) Structural defects either congenital or resulting from disease, i. e., congenital dislocation of the hips, club feet, curvature of the spine, infantile paralysis, tuberculosis of bones and joints, osteomyelitis, rickets, etc.; (c) Postural defects, such as round shoulders, round back, hollow back, flat feet, etc. In many cases operative measures are used to correct deformities and eliminate the use of braces where possible. Bone grafts are used instead of back braces in cases of tuberculosis of the spine or back curvatures. In infantile paralysis, muscle transplants are often done to replace affected muscles, and in many cases of bad fractures, operative procedures are necessary to bring about satisfactory union and position. In many of these cases, operation is however only an incident in the treatment which is carried out in the one or another of the forms of Physical Therapy.

ENGINEERING STUDENTS MAKE INSPECTION TRIP

(*Continued from Page 14*)

With the Electrical Engineers.

Meanwhile the Electrical Engineering group had spent some time at Niagara Falls. The men were not only able to view the marvelous picture of the Falls, but, perhaps more pertinent to an engineering point of view, were able to investigate the transformation of water power into electricity in numerous power plants, and its use in several industrial concerns such as the Kimberley Paper Company, the Carborundum Company, and the Shredded Wheat Company.

The Adams station was one of the most interesting points of visit. It is one of the earliest plants at the Falls, but it still appears as one of the marvels of engineering. It takes water in from a point a fraction of a mile above the Falls and sends it, by means of a very large tube, to the water-wheel turbine about 170 feet below, in a great man-made cavity in the earth. From there the water passes through a tunnel to a point below the Falls where it discharges. There are nearly twenty of these units, which began operation about 1905, and which then furnished some 100,000 horsepower in electrical form. Additions have been made from time to time, especially during the war, until now the capacity is roughly 450,000 horsepower.

An interesting problem arises in the use of such power. The Canadian and American governments have a definite agreement as to the quantity of water to be used by each country. The Canadian or Horseshoe Falls is wearing down very rapidly in the center, and this is causing more and more water to flow over this part of the Falls. The power companies claim that by use of artificial islands and submerged barriers this danger may be averted. A model of the Falls has been built to demonstrate this theory, and the idea is expected to be accepted by the two governments soon. The power companies expect to make Niagara Falls a much more magnificent scene with less water going over than now, thus making more available for industrial use.

The stop at Niagara was perhaps the most pleasant one of the trip. Many opportunities were offered by the Niagara Falls Power Company to see a number of points of interest not usually a part of the route of travellers. The group left for Pittsburgh Sunday afternoon, March 31st.

In Pittsburgh the Electrical Engineers again met the Industrial and Mechanical groups in their visit to the Westinghouse Company and joined them at dinner with Mr. Herr. The Electrical group also visited some of the Carnegie Steel plants, before leaving Pittsburgh for Washington.

The schedule in Washington called for visits to the Bureau of Standards, the National Academy of Arts and Sciences, and the Smithsonian Institution. The exhibits at these places brought out many things of interest to science and engineering. This day in Washington concluded the Electrical Engineering Inspection Trip.

The spring inspection trip is a fitting climax to an extended period of study, providing a more intimate acquaintance and regard for problems of engineering. There is little doubt that a great deal of enduring nature has been gained by the men who made the trip.

GENERAL PRINCIPLES OF SOUND RECORDING

(Continued from Page 31)

magnitude somewhat less than 0.000,05 inch, depending upon the type of emulsion used. The range of volume considered here is extreme, of course, and in practice it is not necessary to record a range of this extent, but it serves to illustrate the extraordinary requirements placed upon the recording medium. When the range of frequencies that are to be reproduced is increased, the surface noise effect becomes greater. As in the case of the different types of distortion discussed above, the difficulties to be met are increased as the quality of reproduction is improved.

Dr. Wente received the Ph.D. degree in mathematics and physics from Yale University in 1918.

Electric Heating, by Edgar A. Wilcox. McGraw-Hill Book Company. 649 pp.

"Electric Heating" by Edgar A. Wilcox is a thorough discussion of all types of electric furnaces, ovens, and heaters. Although design is discussed, the main emphasis is placed upon the application of these devices, with admirable treatment of the economic aspects. It is a valuable book for those who sell or use any type of heating equipment, and for those who supply power for heating loads. W. B. HALL.

THE SIMPLIFICATION OF HIGHWAY TRAFFIC

(Continued from Page 22)

there is a large amount of new material. The C.N.D. Code forms, perhaps, the backbone of the volume and much of the subsequent part is in explanation and amplification of the principles there laid down. Some of the author's ideas may strike the conservative reader as far too revolutionary; others are quite in accord with accepted practice. For he is no wanton idol-smasher, bent on change, but approves the good and condemns the bad, each as he sees it.

One innovation, which is argued convincingly, is that of giving the right of way to a vehicle approaching from the left instead of to one coming from the right. The geometry of this presentation is unassailable, and after reading it one does not have to drive through more than two or three congested crossings to be wholly converted. There is a well planned system of signs, differentiated on the basis of both color and shape. The more general use of pavement markings is advocated and many helpful examples are given, all carefully worked out. The author has made a study of the "psychology of the chalk-line" and has used it to good effect in guiding traffic.

Other questions treated in the book include the rational method of rounding curb corners, dead vehicles on roadways, "which has to do with what is often inaccurately termed 'the parking question'," speed and its relation to danger, and physical changes such as street widening, arcading buildings, etc. An index adds to its value as a standard and important work for reference, study and general reading.

CIVIL ENGINEERING

(Continued from Page 30)

Professor Bishop is Acting Chairman of the Department during Professor Tracy's absence. He has been elected Vice-President of the Connecticut Section of the American Society of Civil Engineers.

Professor Suttie has recently been elected Treasurer of the newly organized New England Sewage Works Association.

The Senior class in Civil Engineering, all of whom are members of the Yale Student Chapter of the American Society of Civil Engineers, have been invited by the Connecticut Section of the Society to a dinner in May.

A public lecture on the "Cascade Tunnel" was delivered under the auspices of the Yale Student Branch of the American Society of Civil Engineers on March 25. The speaker was Mr. J. C. Baxter, Vice-President of A. Guthrie and Company who had been in general charge of the tunnel work.

An illustrated lecture was given before the Yale Student Branch of the American Society of Civil Engineers, April 29, by Mr. J. E. Griffin of the National Paving Brick Manufacturers Association on "Paving Brick."

Professor Tracy's book "Stresses, Statically Determined," is just issuing from the press of John Wiley and Sons, Inc. It is a thorough treatise on statics and stresses within the limits designated in the title. The author has devoted many years to its preparation, and his research has been so thorough that he has been able to treat many important questions, often slighted or overlooked, in a way that will interest the designer as well as the student.

THE SCIENTIST GAZES THROUGH THE CRYSTAL

(Continued from Page 17)

homogeneous substance tends to assume by undisturbed growth.

8. A fine quality of durance or tammy.

These two definitions and the half-dozen I have omitted may be of some use to cross-word puzzle solvers, but we will do well to forget them as irrelevant mental tangle-foot. It is a good deal safer to assume that anything solid enough to pick up in one piece contains one or more crystals, and to leave the burden of proof on anybody rash enough to uphold the contrary. Having thus, like Francis Bacon, taken all knowledge for his province, the crystal physicist has no rival except the colloid chemist—I like to think that the first noun may help to describe the second in both cases—who is equally anxious to annex the visible universe. In the conflict of these champions it would ill become me, an interested party, to act as referee. Much doubtless remains to be said on both sides.

The Study of Crystals is Important

The interesting thing about crystals is, then, that the more we know about them the more we know about solid bodies, and since all our well-known world—including ourselves—

would flow gently (like sweet Afton) into a kind of cosmic mush if solid bodies did not stay that way, the study of crystals ought to help us in keeping the aforesaid world in working order. With this important end in mind several laboratories are now set apart for the study of crystals. They may be classified roughly into those in which visible light or the near ultra-violet is used for the examination, and those in which the ultra-ultra-violet or x-ray region is employed. An example of the latter has recently been equipped in the Sloane Physics Laboratory. The two methods of study are entirely different in operation and tell us different things. A notion of the difference can be drawn from a fairly close analogy.

A balloonist a mile above the earth might find out something about the shape of the land beneath him by sounding a horn and listening to the echoes. If he were very skillful he might even detect the difference between the echo from paved streets and that from open country. But a searchlight would tell him much more. He would still, to be sure, be observing echoes of a sort, but light echoes have more detail in them than sound echoes, mainly because the waves of light are so much shorter than the waves of sound.

There is a similar difference in scale between X-rays and light, although here the two sorts of waves differ only in wave-length, and even in this respect are nearer alike than are sound and light waves. Where examination by light can tell us that adjacent metal crystals in a polished specimen are differently attacked by etching agents, examination by X-rays can tell us the spacing and arrangement of the atoms in a single crystal and exactly how adjacent crystals differ in these respects.

Determining the Differences in Quality of Metals

A pressing reason for being so inquisitive about the internal working of crystals, especially metal crystals, is that manufactured metal parts so often differ in quality for mysterious reasons. There are two ways of dealing with such differences. The time-honored way is to remember at all times that strength, magnetic permeability, resistance to corrosion or what-not may vary between limits more or less well known, and to make sure that we do not specify the quality in question too exactly. This is, of course, the right way as long as the average quality is plenty good enough, but manufacturers have a nasty habit of wanting to make everything better than average, if I may be permitted this "bull". In order to do this it becomes necessary to know just how the best piece differs from that which is not so good. All the methods of study have advantages and limitations. Consider some of the former.

Mechanical and magnetic tests measure differences of the same kind as those to be explained and are therefore ideal for inspection purposes. Chemical analysis tells what kinds of atoms are present, and how many of each kind, and is capable of extreme refinement in distinguishing different materials. Optical analysis tells how many different materials are present in visibly separate bits and what some of them are in a chemical sense. Since "seeing is believing," this is an especially convincing method of study. X-ray analysis tells how the atoms are put together in each bit and whether the separate bits are arranged in any special way. It gives the most fundamental information of all. When the story is complete it may be found that successful duplication of an accidental triumph requires only one of the many steps in manufacture to be closely controlled. If we keep our wits about us we may find that a much higher degree of some desirable property can be attained by going deliberately a little farther in a direction where accidental differences show improvement to be possible.

Some day we may be able to make metals to order so that they suit a particular need as closely as the telephone instrument

on your desk suits your need for conversation with distant persons. Before that time comes there is much to be found out about what statisticians like to call the correlation between crystal structure and physical properties. The whole

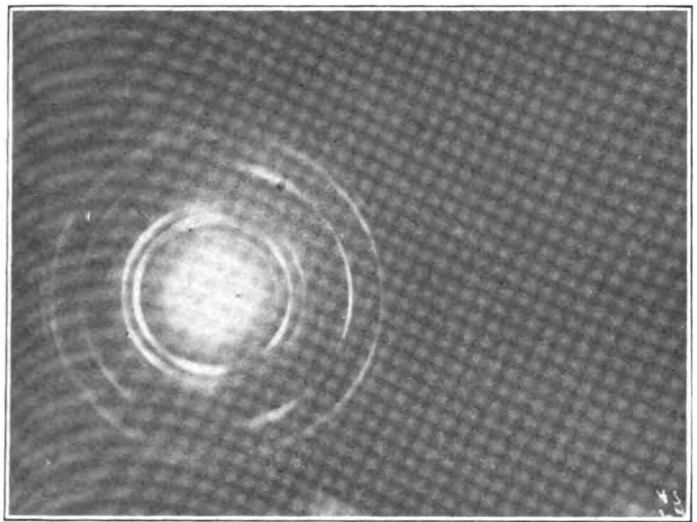


FIG. 4. *Diffraction pattern due to 0.5 mill rolled permalloy sheet. Molybdenum x-rays as in Fig. 2. Photograph, taken on plate, shows very small crystals and a preferred position for their axes as indicated by non-uniformity of circles in the pattern. Nature and degree of preference can be determined from this picture.*

subject is less than eighteen years old and it is too soon to say how much use may yet be made of the method. The pictures with this note give some idea of the form in which the data for X-ray analysis appear.

One way to trap a beaver

NOT everybody in the Hudson's Bay Company was a trapper, any more than everybody in the Bell System is a telephone engineer.

The Hudson's Bay people trapped a good many beavers in the company offices, where the skilful financing and careful business management served to back up the men actually on the front lines. Organized activity succeeded then just as it does today. The men who put up telephone lines can work the better because back of them are other men who painstakingly design and make their equipment, and still other men who correlate all these activities into a smoothly meshing plan.

—nor is every man at Western Electric an electrical engineer

THE vast manufacturing industry of the Western Electric Company—a business of well over 250 million dollars annually—embraces activities not only in electrical and mechanical engineering but also in many non-technical fields.

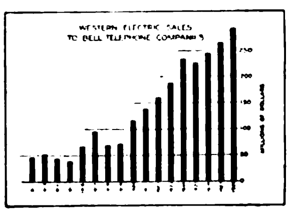
Buying everything from grass seed to telephone poles

For example, economics and business management play important parts in gearing the entire physical plant and production schedule to the country's future requirements for telephone service.

Moreover, Western Electric not only buys or makes everything the Bell System uses but delivers it where and when needed.

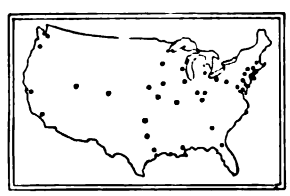
A nation-wide warehousing and distributing system has been developed that meets the highest standards of modern business practice.

Thus work in Western Electric appeals to men who later on may develop aptitudes for merchandising, statistical analysis and business administration.



An interesting work is the preparation of statistical studies of the Company's activities and the analysis of general business conditions in this country and abroad.

A nation-wide service of supply. At 32 important points Western Electric maintains stocks to be drawn upon as needed by the telephone companies.



BELL SYSTEM

A nation-wide system of inter-connecting telephones

"OUR PIONEERING WORK HAS JUST BEGUN"

PERSONALITIES

(Continued from Page 27)

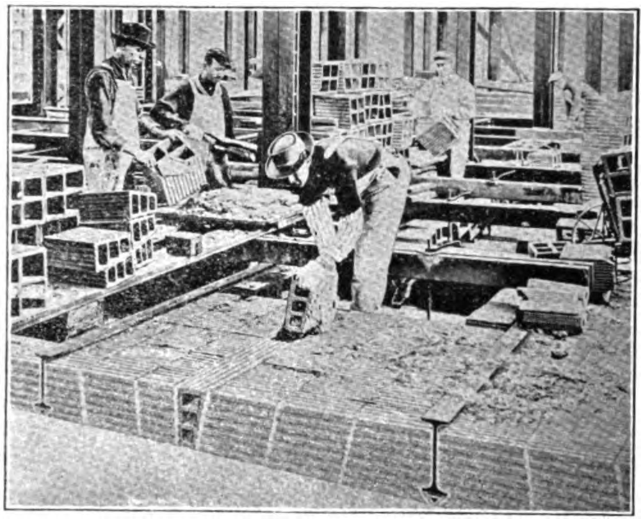
opportunities to observe the operations in the mill and this served to increase his interest in the application of chemistry to industry. Following his graduation in 1908, Curtis was appointed an instructor in chemistry at Colorado and remained there for five years. In 1913 he left to become a teaching fellow at the University of Wisconsin. Here he did graduate work and received the Doctor's degree in 1914, his graduate research being in the field of photo-chemistry. He then returned to Colorado as professor of physical chemistry. In the spring and summer of 1916 he served for six months on the Mexican border with the Colorado National Guard cavalry. When war was declared in 1917 he was again called into service with the Colorado cavalry but was soon transferred to the Nitrate Division of the Ordnance Department. For the next two years he was engaged on various chemical engineering projects for the Ordnance Department, spending most of the time at the experimental station at Sheffield, Alabama. While there he built and operated an experimental ammonia oxidation plant. He also helped to establish the Fixed Nitrogen Research Laboratory at Washington where all the experimental work of the nitrate division was consolidated after the war.

In the fall of 1919 he returned to teaching as professor of chemistry at Northwestern University. Finding conditions there unsatisfactory at that time, he left in February, 1920, to become chief chemist for the International Coal Products Corporation. This was his first work in the field of coal carbonization which has since engaged much of his attention. In the fall of the same year he was made superintendent of the plant at Irvington, N. J., and in the following spring went to Clinchfield, Va., as general manager of the Clinchfield Carbocoal Corporation, where he was in charge of a large coal carbonization plant. As a result of two years work, the plant was proved to be not economically feasible. In the spring of 1923 he left to undertake a nitrogen survey for the United States Department of Commerce. The following September he came to Yale as professor of chemical engineering.

His outstanding work at Yale has been the complete reorganization of the old course in industrial and engineering chemistry into a modern course in chemical engineering. In fact Chemical Engineering at Yale is practically synonomous with the name Curtis. Before he was called to head the course, Yale had lagged behind other leading institutions in the development of one of the oldest, if not the oldest, of the engineering professions. With characteristic energy he plunged into the task of building up this course, and providing suitable laboratory facilities. His suc-

(Continued on Page 40)

FLOORS



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PERSONALITIES

(Continued from Page 38)

cess may be judged by the fact that in 1925, only two years after he came here, a committee of the American Institute of Chemical Engineers appointed to investigate courses in chemical engineering, published an approved list of fourteen institutions of which Yale was one.

In addition to his teaching, many other professional activities have occupied his time. In 1925 he served as a member of President Coolidge's Muscle Shoals Commission which made a study of the best means for utilizing the Muscle Shoals plants. He is a consultant for the Fixed Nitrogen Laboratory and for various industrial organizations, and has recently investigated certain chemical engineering projects in Europe in connection with this work. In 1928 he represented the United States Department of Agriculture at the International Nitrogen Conference held on board the steamer "Lutzow" in the Adriatic. After this conference he made a study of the nitrogen industry in several European countries.

He has published a number of papers in technical journals on various phases of coal carbonization and nitrogen fixation and his work in these two fields has won him an international reputation. Further recognition of his work came in June, 1928, when the University of Colorado conferred upon him the honorary degree of Doctor of Science.

In spite of his many purely professional activities he has found the time to take an active part in the affairs of Alpha Chi Sigma, the chemical professional fraternity, serving seven years as a member of the Supreme Council and five years as national president. At present he holds the office of Fraternity Historian and recently published in book form a history of the fraternity.

Dr. Curtis' chief pleasure in life seems to be hard work. He has no hobbies to while away his leisure hours for it is doubtful if many of the latter exist for him. He does enjoy reading and has read widely if one may judge by the diversity of subjects with which he impresses one as being conversant. His gift of story-telling is unusual. If you catch him in one of his few leisure moments just after lunch or dinner, when that ubiquitous cigar has been lighted, he will spin you a yarn about his early days on the ranch or about his experiences at Clinchfield that will hold your attention from beginning to end.

His office door is always wide open when he is there, and in the course of a day, men of widely different positions, from students to presidents of large industrial corporations, enter it. They all find there a sympathetic listener to their problems and all are impressed by his quiet but forceful manner. Those who have been most closely associated with him in work have learned that when he has made up his mind to do a thing, he somehow brushes aside all obstacles, and finishes the job.

B. F. D.

Handbook of Mechanical Refrigeration, by H. J. Macintire, M.M.E., Univ. of Illinois. Published by John Wiley & Sons, New York, 1928. $6.00.

An especially valuable book for practical design, installation and operation of refrigerating equipment. For instructional work the fundamental principles of thermodynamics would probably have to be supplemented from other sources.

This book can be safely recommended as a valuable one for the reference library. L. E. SEELEY.

THE PRESENT-DAY TREND IN BIOLOGY

(Continued from Page 12)

working tools in many of our scientific papers. Chemistry has long been a very vital factor in biology. Nutrition and the effects of experimental nutritional modifications have formed an ever increasingly important branch of biological research. Physics is contributing an increasingly important share to our fund of biological methods of investigation. The use of x-rays in the field of genetics and ultra violet light in both therapy and microscopy are simply a few of the contributions of this science to present day Biology.

Research uncovers facts in each individual field; later they are correlated by workers in other branches of science. Because of this, preparation for research has become increasingly difficult. One must be more interested in what is occurring in other scientific fields than ever before. One must know the methods available in the various branches of science intimately enough to apply them to the solution of a given scientific problem.

It is, of course, obvious that no one can become a specialist in the whole field of Chemistry, Physics, Mathematics, and Biology but one can have a fundamental working basis from each of these sciences with which to work in that particular field to which they wish to apply it. The experimental method of today definitely indicates the future development of this type of correlated scientific endeavor.

THE VALUE OF AN ENGINEERING EDUCATION

(Continued from Page 8)

fight." Now if Yale has this prestige, this atmosphere and this undefinable spirit of leadership, why not specialize by training her students to be leaders and not followers in their life careers? Instead of attempting to compete with the best technical schools in the country by matching their intensive specialization, leave that field to the schools which can occupy it better than Yale could hope to do, even after many years of sustained development. Let Yale utilize her own peculiar advantages to the full —let her capitalize, if you please, her traditions, her spirit of leadership and train her sons to be the Employers in Industry, leaving to other schools that much larger field, the training of Employees. As an enterprising New Haven Ice Cream maker advertises, "We cannot make all the Ice Cream so we only make the Best."

How long do you suppose it would take, once such a policy became effective and was generally known, before every big business leader in the country would want his son to go to Yale, so that he might have the best possible chance to follow in his father's foot-steps?

A NEW COURSE OFFERED TO SHEFF STUDENTS

(Continued from Page 15)

and Valuation, 3 hrs.; Econ. 50, Railroad Transportation, 4 hrs.; Econ. 54a, Banking, 3 hrs.; I. E. 13b, Transportation, 3 hrs.

(c) *Statistics and Business Forecasting:* Econ. 58b, Business and Financial Forecasting, 3 hrs.; Econ. 59a, Statistical Evidence, 3 hrs.; Econ. 59b, Problems in Economic Statistics, 3 hrs.; Math. 26a, b, Higher Algebra, 6 hrs.; Math. 28a, Mathematics of Investment, 3 hrs.; Math. 29b, Mathematical Statistics, 3 hrs.

THE YALE BOTANICAL GARDEN AND PRESERVE

(Continued from Page 6)

woody plants. To a certain extent also it is being attempted at the Garden to grow, under conditions simulating those of nature, various plants which do not take kindly to ordinary methods of cultivation. But projects relating to the growth of plants under natural conditions, in large part at any rate, may much more satisfactorily be tried out at the Natural Preserve, to be described presently.

One other phase of Garden activity merits brief mention in passing, since it is one of much practical value to the University, and that is the securing and propagation of plants for general University planting. Large numbers of shrubs in particular are grown from seeds or cuttings, in the greenhouse and in a nursery plot set aside for the purpose, being kept here until they reach such size that they can safely be transplanted to the large University nursery in Hamden.

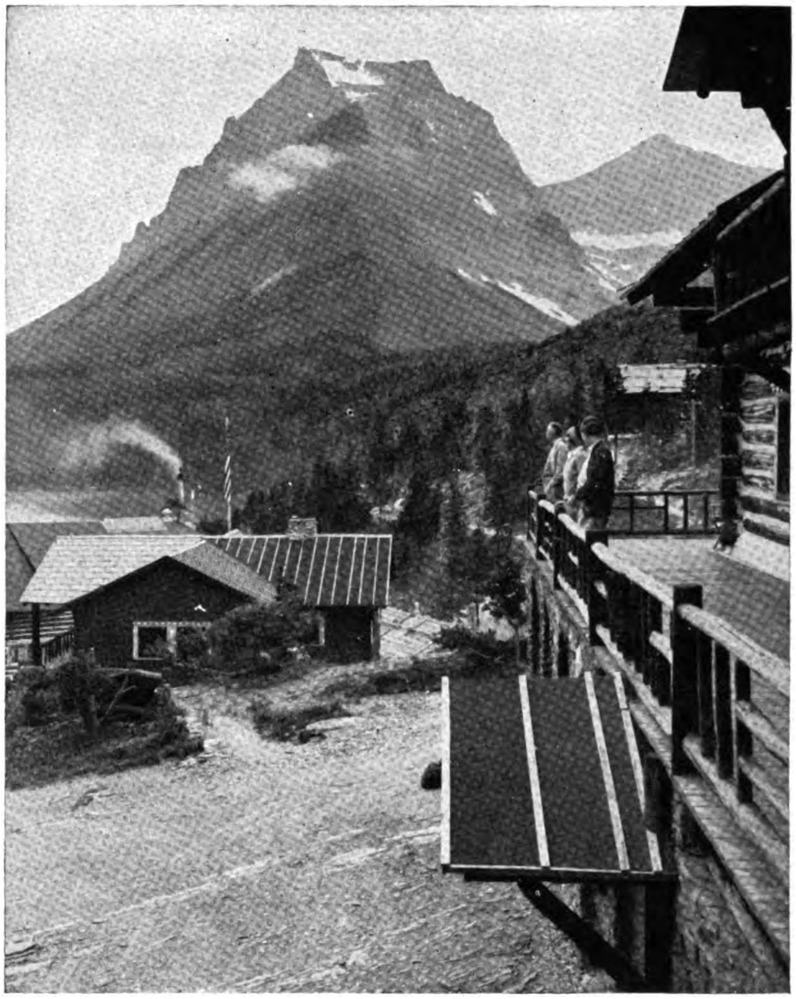
The Yale Natural Preserve

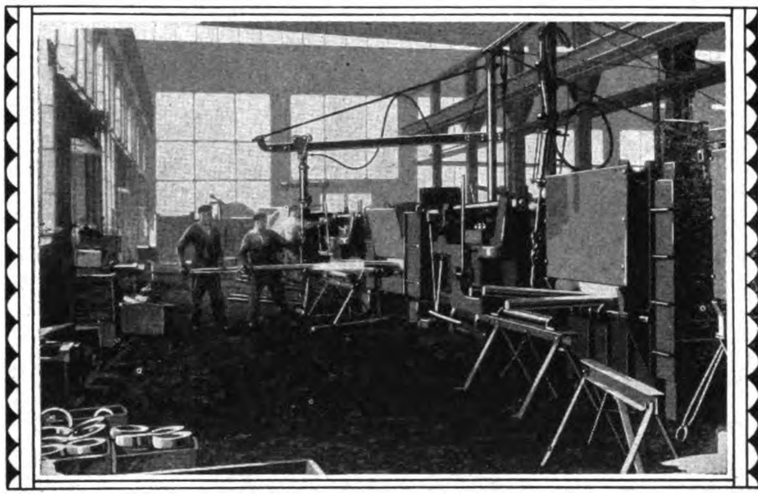
The Natural Preserve is located along the western side of the Ray Tompkins Memorial, bordering the far side of the golf course. It comprises a strip of land running north-and-south for more than a mile, with an average width of about a third of a mile, and an area of about 200 acres. It is a rugged and diversified piece of country, with numerous rocky ridges and swamps and a few small ponds and brooks. It is almost wholly wooded with oaks, hickories, red maple, and a wide variety of other trees. More than a hundred kinds of trees and shrubs, together with several hundred different kinds of herbaceous plants, are known to grow here naturally. The area is traversed by a system of wood-roads and trails which render most parts of it readily accessible. It has been set aside by the University as a reservation, to be maintained in large part in a natural condition and for purposes of instruction, experiment and research in various phases of natural history.

By far the most ambitious project contemplated in the Preserve is that of restoring the forest to its original condition. By judicious planting and other treatment over the larger part of the area, it is planned to bring about the development of a mixed forest of evergreens and hardwoods, one which in course of time will come to resemble the primeval forests which prevailed over much of southern New England in the early days but which have long since been destroyed. As a start toward this objective, during the past four years nearly 10,000 young hemlocks, formerly one of the abundant trees here, together with a considerable number of white pines and sugar maples, have been planted over various parts of the tract, while about 7000 seedlings of hemlock have been temporarily planted out in a nursery established on the grounds this spring. Along some of the main trails, and locally elsewhere, the woods have been opened up by the removal of unsightly trees and brush, but for the most part such clearing is being done only with a view to aiding Nature in the rehabilitation of the forest.

One selected tract of about 12 acres has been surrounded by a high wire-mesh fence and designated as a wild plant and bird sanctuary. The area includes a swamp and a small stream which has been dammed up to form a pond (Fig. 4). It includes a variety of habitats, and already a large number of rare or otherwise interesting plants have been set out here—plants such as the showy lady's slipper (Fig. 5) and trailing arbutus which it is desired to have accessible but which can not be successfully grown at the Garden. Considerable areas within the sanctuary have been cleared of woods and planted to berry-producing shrubs

(Continued on Page 46)





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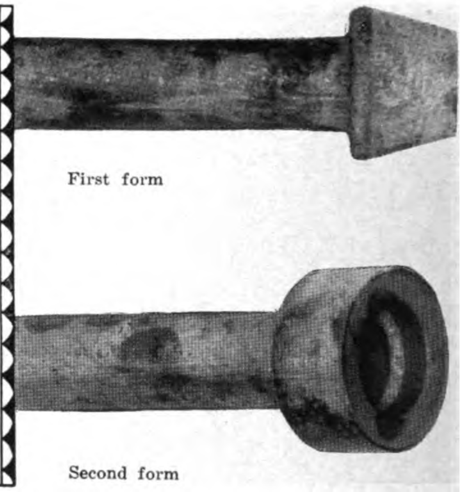
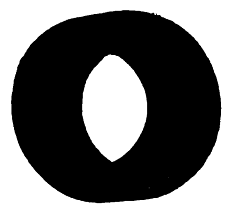


Completed forging



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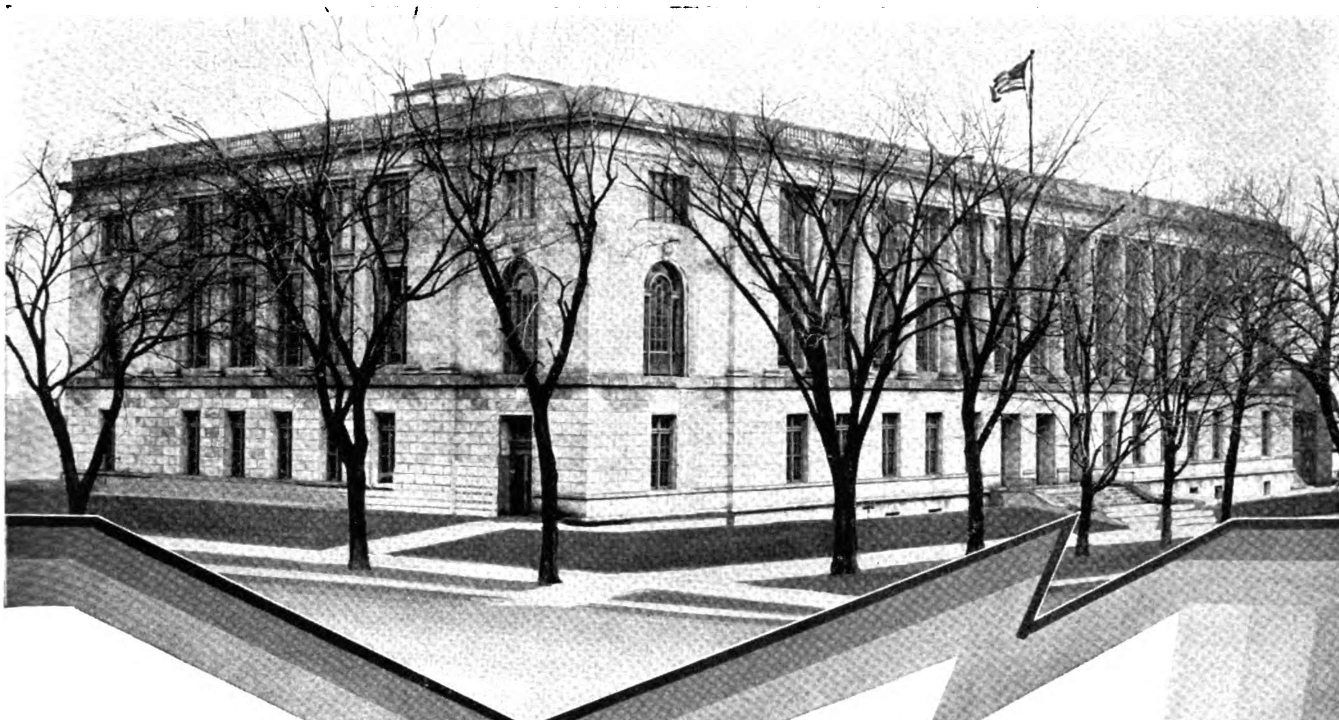

Koehring-Mixed Foundation
for Federal Building

Probably one of the most interesting and attractive of the federal buildings erected during the last year is the United States Post Office and Court House at Madison, Wisconsin. In addition it is one of the first in the building program resumed since the World War.

Situated in the shadow of the state capitol and only a few hundred feet from Lake Monona, one of the four lakes which surround Madison, the three-story building of Bedford stone has an ideal setting.

Employing the latest methods in the interior transfer of mails the Post Office department arranged the rooms, conveying machinery and platforms to bring about greater ease and speed in the handling of all classes of mail.

In the main lobby, marble slabs cover the walls from the floor to a height of eight feet. Quarter-sawed oak is the interior finish throughout the building.

Despite other unique features found in the Madison Post Office, its foundation of dominant strength concrete is similar to that of other well-known building projects throughout the world — concrete mixed by a Koehring.

The ingredients of concrete are the same in all cases but the Koehring re-mixing action — a fundamental principle of Koehring concrete mixers and pavers — coats every particle of sand and gravel with cement to produce dominant strength concrete.

"Concrete—Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, will be gladly sent on request to engineering students, faculty members and others interested.

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THE YALE BOTANICAL GARDEN AND PRESERVE

(Continued from Page 42)

or small trees of recognized food value to birds. A small portable house has also been erected here to serve as a workshop and general headquarters for the custodian.

Admission to the sanctuary requires special permission. But the larger part of the Preserve, under certain restrictions, is open to the public, the main entrance being on Fountain Street, about a mile west of the Edgewood trolley terminus. It is planned to increase the recreational value of the area, so far as this can be done without interfering with the objectives for which the Preserve was primarily founded, and to this end the old wood-roads have been brushed out and made passable for trampers and horse-back riders, while several new trails have been established. Two years ago a nature trail was laid out, with nearly a hundred trees and shrubs along the way clearly labeled, and it is planned to develop certain limited portions of the tract as an arboretum for the growth of native American trees. Various pieces of experimental and investigative work are contemplated, particularly such as embody observations extending over a period of years and which require continued freedom from disturbance. Already several of these studies are under way.

The organization in charge of the Preserve comprises a local University Committee, made up of representatives from the Departments of Botany, Forestry, and Zoology, and a Graduate Advisory Council consisting of George T. Adee, '95, Starling W. Childs, '91, Samuel H. Fisher, '89, Marcus Goodbody, '97S, Robert W. Pomeroy, '91, and Frederic C. Walcott, '91. The funds necessary to initiate and carry on the work at the Preserve have been generously provided by members of the Graduate Advisory Council and other interested alumni and friends of Yale.

OUR CONTRIBUTORS

(Continued from Page 8)

went into the research department of the Bell Telephone Laboratories.

¶ *Luther Simjian, who contributes "Photography at the Yale School of Medicine," is an Armenian by birth. He came to this country in 1921 after harrowing experiences during the latter part of the World War. He first became Laboratory Assistant in Surgery at the Yale Medical School, and then Technician in Medicine. Last year he was put in charge of the Photographic Department of the Medical School. He has given exhibitions of his photographic work in New Haven, and some of his studies of Harkness are well known.*

¶ *Prof. Charles J. Tilden, who writes on William Phelps Eno, graduated from Harvard in 1896. He has been an engineer on the New York Transit Commission, Instructor in Engineering Mechanics at Cornell, Head of the Department at Michigan, Professor at Johns Hopkins, and came to Yale as Professor in 1918. He has received an honorary M.A. from Yale and is a Sterling Professor. During the War he served on the Council of National Defense.*

¶ *Charles H. Warren has written for this issue an article introducing a new course in Sheff. Dean Warner received his B.S. from the Sheffield Scientific School of Yale University in 1896 and his Ph. D. in 1899. From 1912 to 1922 he was Professor of Mineralogy at the Massachusetts Institute of Technology. Mr. Warren has been Dean of Sheff. and Sterling Professor of Geology since 1922.*

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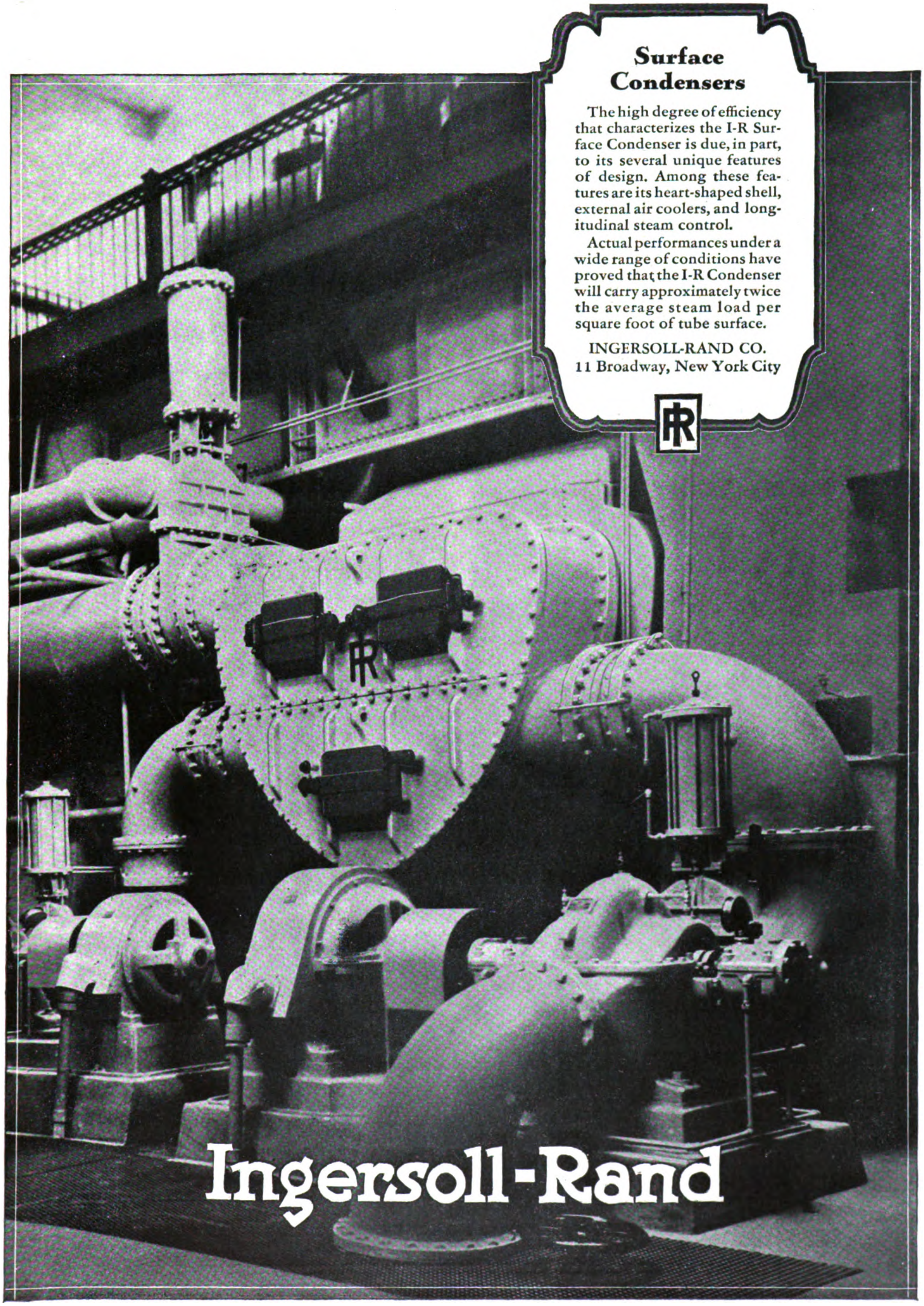
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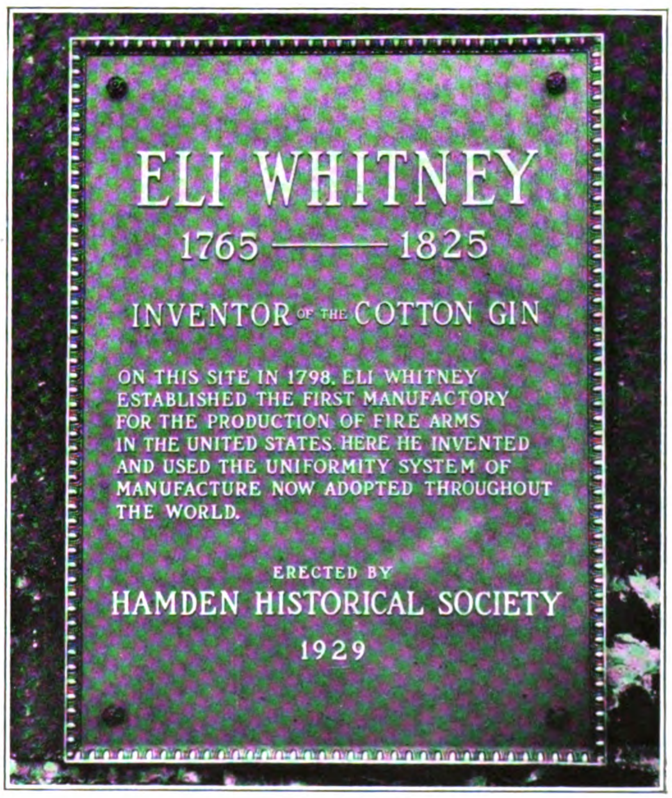
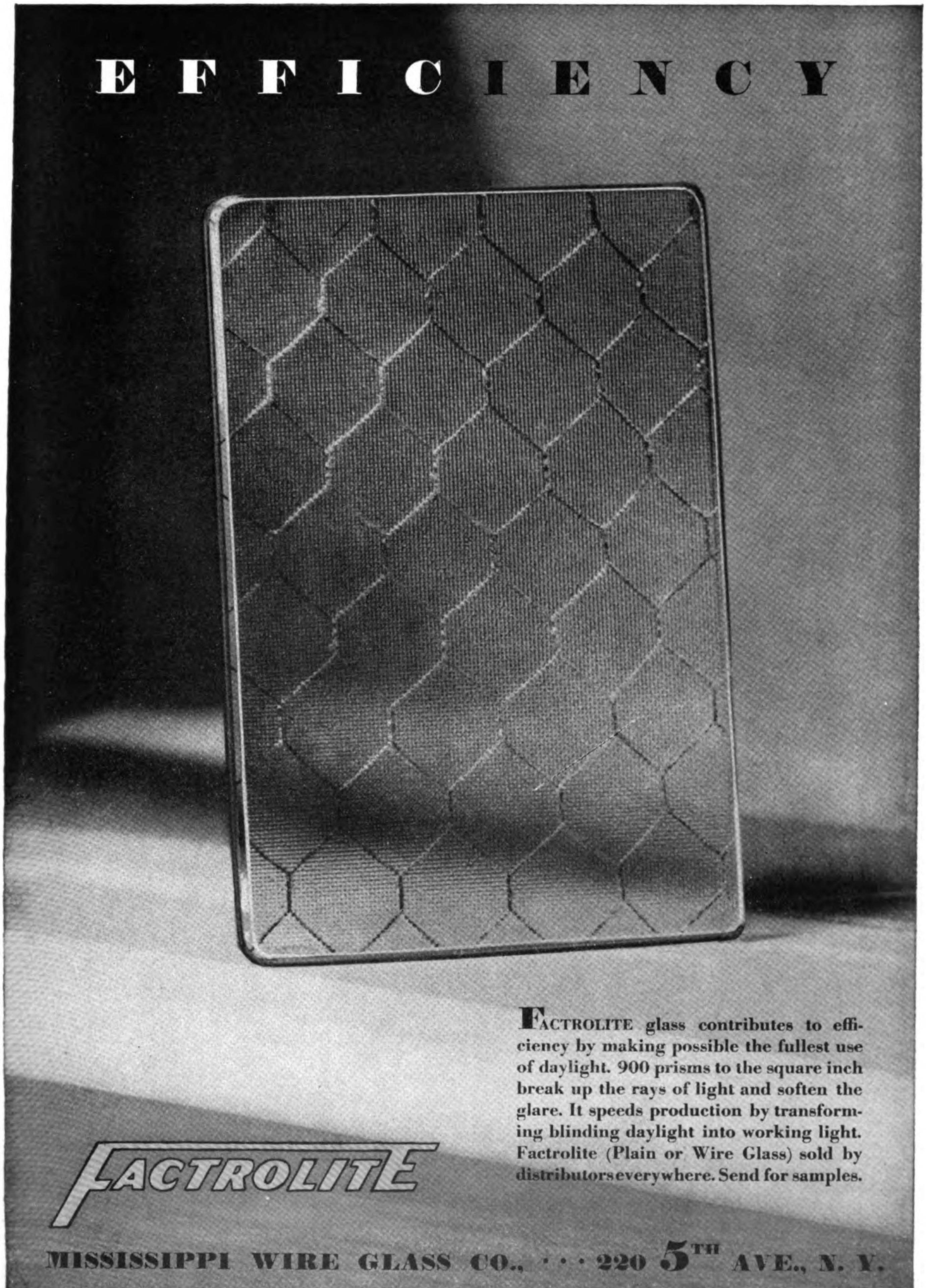


WHITNEY MEMORIAL TABLET, HAMDEN, CONN.

(*See page 5*)

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL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THE YALE SCIENTIFIC MAGAZINE

C O N T E N T S

VOL. IV — NOVEMBER, 1929 — No. 1

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Subscription rate, $1.50 per year. Single copies, 40 cents. Advertising rates upon application.

THIS message is primarily for the members of the Freshman class. It is intended to announce a somewhat radical change in the policy of the Yale Scientific Magazine. The Sheffield Scientific School is not very well represented in the publications of the undergraduates of the University, a condition not to be blamed on them, but on the relatively small number of Sheff. men on their various boards. The editors of this magazine, published exclusively by students in the Scientific School, feel that it should report undergraduate opinion and activities pertaining particularly to Sheff.

Heretofore the scope of this sort of material has been limited largely to descriptions of laboratory exhibitions, inspection trips, and allied subjects. We intend to extend this field in some degree by publishing undergraduate opinion of undergraduate reaction to Sheff. life. Recent years have seen an increase in the enrollment in Yale college, and a corresponding decrease in enrollment in the Scientific School. There are numerous reasons cited for this movement. But in our opinion one important reason is the fact that the idea of enrolling in the College is predominant because the College has a greater influence on the life of the Freshman Class. In the nature of an experiment, therefore, beginning with the January issue, the Yale Scientific Magazine will publish occasional articles by prominent undergraduates in the University giving their ideas and those of others on the subject of choices which come at the end of the Freshman year.

The Editors.

Eli Whitney, An Appreciation of His Life

By A. J. Ralph
President, Hamden Historical Society

TWO of the outstanding factors in American history have been the relations with the negro race involving the Civil War and the subsequent adjustments and present problems, and secondly, the industrial development of the country. Eli Whitney, a Yale graduate and a resident of New Haven, and his New Haven factories were important initial factors in both of these movements.

The invention of the cotton gin by Eli Whitney was the beginning of the cotton industry. The resulting need for labor in the cotton field was met by the importation of negroes from Africa. The early cotton gins were made in a factory on Wooster Street in New Haven.

The failure in litigation to maintain his patent rights and his financial struggle eventuated in his development of the manufacture of firearms by the "uniformity system", in which uniformity of manufacture of parts produced interchangeable parts. The manufacture of similar separate parts and their assembly into finished machines introduced in the arms factory at the present site of the Whitney Lake Dam in the town of Hamden, adjoining New Haven, has become the fundamental method in the production of all machinery and is a basic principle of American industry.

A tablet commemorative of Whitney and his achievements was erected by the Hamden Historical Society and was dedicated on June 29th, 1929. It is on the West Wall of the Dam facing Whitney Avenue where the Avenue makes a turn and ascends to the level of the Lake.

Dr. Maurer's Dedication Address.

At the dedication exercises Dr. Oscar E. Maurer, Pastor of Center Church, spoke in part as follows:

We hereby dedicate this Tablet to the memory of Eli Whitney, graduate of Yale College, school master, inventor and citizen, whose genius, within the space of his own lifetime, effected two changes in industry so radical as to be virtually new creations.

This Tablet commemorates his invention of the cotton gin, which transformed the entire cotton-raising section of the United States and called into being the great textile centers of Old and New England, profoundly affecting not only the industry of the world, but also the economic and social status of millions of human beings.

Even more, the Tablet is a tribute to the spirit which, though cast down, is not destroyed. Unjustly deprived of the fruits of his invention, reduced to poverty by the cost of litigation in its defence, Eli Whitney was superior to defeat and discouragement. Refusing to allow his spirit to sink into the futility of bitterness he applied his genius to a new creative task.

And therefore, we are able, through this Tablet, to commemorate the second fundamental achievement of the man whose name we are proud to honor. By his applications of the principle of division of labor through the standardization of parts, Eli Whitney not only served his country in its time of need, but he also revolutionized the method of manufacturing, making possible the quantity production which characterizes American manufacture and which has placed it in the forefront of the industrial world.

The Beginnings of Modern Industry.

There is a growing interest in seeking the origin of the influences which have moulded our political, economic, and social life. We have developed a continent and a new industrial era, and now we can review the work which has made this possible. The pioneer did great things in preparing the way for advancing civilization; education has stabilized conditions as they were developed. Eli Whitney, himself a graduate, placed a high estimate on the value of college training; in this he had vision and sought education, not only for himself, but also for others. In the period following the Revolution leaders were called for in local government and in industry. The suppression by England of the industrial arts in the Colonies had made a dearth of mechanical skill. There were no machine tools available and very little material. Henry Maudsley's screw cutting lathe was invented about the time that Eli Whitney bought the old flour mill, built in 1666, which had furnished flour and meal for the hardy Colonists for more than a century. "A new demand for accurate tools arose during these years springing from the inventions of Arkwright, Whitney, Watt, Fulton, Stephenson and others." The above quotation is from Professor J. W. Roe's book "English and American Tool Builders" which places Eli Whitney on a plane with the great men of his time.

In person, Mr. Whitney was tall and dignified. He had a cultivated mind and a manner at once frank and agreeable. He was familiar with the best society of his day and was a friend of every President of the United States from George Washington to John Quincy Adams. He had a commanding influence among all who knew him. Seldom has a great inventor been more sane, for his powers of invention were under perfect control and never ran wild. Unlike those who devise many things but complete few, he left nothing half executed. Robert Fulton said that "Arkwright, Watt and Whitney were the three of his contemporaries who had done the most for mankind." Eli Whitney was pioneer in community life for his employees giving to his men of his large experience and character, living with them and sharing their conditions. He knew men and cared for their comfort more than for his own. He provided Colony homes for them which were masterpieces of that time. He selected men who would be his permanent helpers and thus established a business which was successful for more than one hundred years. Eli Whitney invented the machinery and tools he used in his work; his first milling machine is in Mason Laboratory, Yale University. The first money for his college education was earned by machines he devised for making nails and knife blades. He practiced and taught self help and thus ministered to the economic life of the Nation. He saw that to survive as a Nation defence must be provided. His foresight in providing manufacturing facilities was justified when in the War of 1812, 25,000 of his muskets were made for the Government at the Whitney Armory.

(Continued on page 33)

The Life of the Protozoa in Termites

The Study of these Flagellates Shows Them to have a Definite and Necessary Function in the Life of the White Ant.

By C. Courson Zeliff

WE know very well that human beings occupy some of the most remote parts of the earth. There is hardly any place that is too warm or cold, whether it be bleak or pleasant, that is not chosen by some branch of the human family. So it is with the other members of the animal kingdom from the lowest to the highest. They may be found in the darkest caves, under stones, or in almost any organ or part of some other animal. There is practically no large plant or animal living that does not serve for the abode of several other plants or animals. We are not able to explain how these forms came to be adapted to life within some other type save as a matter of chance. To them, apparently, there is life and happiness in these seemingly undesirable places, possibly more than in the free and open places from which they have come. The intestines of animals has been an excellent place for many of the lower forms of life, such as the bacteria, to locate because of the easy access and abundant food supply. There is, however, the liver fluke which is most at ease in its adult stage in the liver of various animals. In the study of minute forms of animal life in the intestines of animals there is no group more facinating than the microscopic ones found in the intestine of the white ant. They belong to the protozoa or basal branch of the animal tree, and they are collectively known as flagellates since they have long hair-like outgrowths which are called flagella—meaning a whip or whips.

The credit for the first real interest in and the discovery of these bizarre and peculiar animals must be given to Dr. Joseph Leidy, one of our famous American Zoologists. He was professor of Zoology at the University of Pennsylvania and published his first account in 1877. Among the many to study them since that time are Grassi, Janicki, Kofoid, Kirby, and Cleveland; the last being mainly interested in the relation between the protozoa and their hosts the white ants or termites.

It will not be necessary to say much about the white ants themselves since much has been written about them both from a popular and scientific standpoint. They are highly organized like the common ant. They are not, however, very closely related even if they do bear the name of ant. Indeed, they have queens, soldiers, and workers like the ordinary ant, but the name termite is to be preferred. The termite lives chiefly on wood, and recently at Yale some timbers under one of the faculty club houses had to be replaced because of them. In recently replacing a bulletin board also, the posts under the ground were found to have been destroyed by *reticulotermes flavipes*, the only termite that lives in this locality. Ants were living with the termites in this case and when disturbed they seem to have held the termite responsible for they were attacking them and carrying them away. Dr. T. E. Snyder of the Bureau of Entomology of the United States Department of Agriculture is a foremost authority on the classification of termites.

The termite gets its food from the wood which it eats and which is largely cellulose. The protozoa or flagellates are apparently indispensable to the animal for they ingest or eat the wood and then give up the digested material to the host or are in turn digested by the termite. By treating the termite with oxygen it has been possible to clear the intestine of all the flagellates but the termites do not live for any length of time. Here, then is one of the most interesting cases of dependence in nature. There are a great number of spiral shaped and other rod-like bacteria in the termite but none of these have been found to digest cellulose as some do under other conditions in nature. In this connection it will be interesting to recall that the cows stomach contains a huge number of related forms of protozoa. They are found in more than ordinary abundance in the camel and most animals that eat coarse foods containing cellulose. The most healthy cows have the most protozoa, but whether they do any digesting is not known. In the flagellates in the illustration one may observe the pieces of wood in the body of the flagellates. Recently, Montalenti has been able to keep termites for several months by feeding them soluble starch alone or in combination with glucose. The protozoa fauna disappeared gradually. The final death of the termite was probably due to other causes.

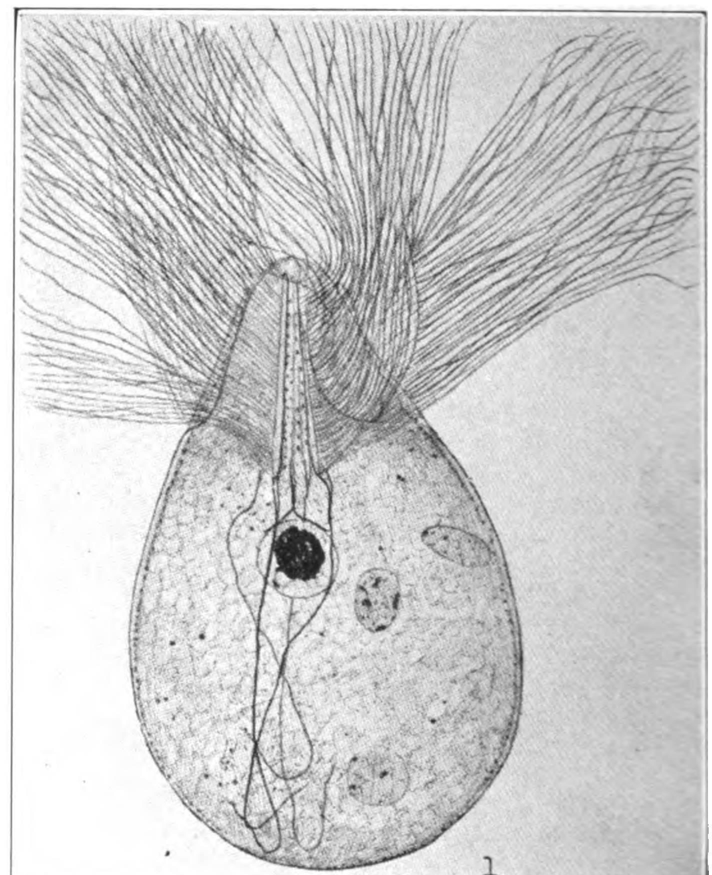


Fig. 1. Staurojoenina (after Kirby).

(Continued on page 31)

Chemistry and the Quantitative Method

The Development of Chemical Technique From the Time of Galileo to the Present.

By Professor Herbert S. Harned

WHEN the investigations of Galileo, Kepler and Newton demonstrated that the motion of heavenly bodies and the motion of bodies on this earth could be calculated with great accuracy by the same master equations, a new point of view towards the world about us came into being. The application of a little theory, a little logic and mathematics made possible the accurate prediction of a certain class of phenomena. When Lavoisier introduced into the study of the world of substances a simple device called the balance, quantitative method became available and chemistry as we now understand it had its beginning. The extraordinary thing about this latter instrument is the quantity of information regarding substances which has been obtained by its use alone. The balance is largely responsible for the development of analytical chemistry, the study of atomic masses and the periodic system of the elements, and the immense development of structural organic and inorganic chemistry.

To-day similar processes are going on but the situation has become much more complex. Scientists keep on inventing methods of measurement and by their use enormous volumes of data are being added to our fund of quantitative material. Incessant criticism and reconstruction of points of view are leading to continually renewed attempts to interpret the results obtained by means of the older or more recently invented mathematical physics. Consequently, the chemist is now employing a great many instruments and other special experimental devices, and a considerable amount of mathematical physics in order to answer the complex questions in which he in particular is interested. As a result of this state of affairs and according to the custom of nature, we should expect that at some time and in some place, a child would be born which would be too much like physics to be chemistry and too much like chemistry to be physics. It requires little intellectual effort to name this offspring "physical chemistry."

Physical chemistry as it is recognized to-day was really founded by the efforts of a Dutchman, van't Hoff, a Swede, Arrhenius, a German, Ostwald, and an American, a Yale Professor, J. Willard Gibbs. van't Hoff recognized the great importance of thermodynamics for the study of chemical phenomena and applied its fundamental laws with consummate skill to the intricate problems of chemical equilibria. Arrhenius invented "the ionic theory" or "the classic theory of electrolytic solutions" which was and still is destined to play an extremely important role in the development of chemistry. Ostwald, although not so original as van't Hoff and Arrhenius, was a great organizer of the data then available upon which a border line subject such as physical chemistry might be based. Gibbs was the mathematical physicist who some years earlier had completely worked out the thermodynamic theory necessary for these studies.

By following the investigations of the founders of this subject, we find ourselves using the laws and theories which have been devised to deal with collections of enormous numbers of molecules. The chemist is vitally interested in predicting how such systems will behave and the effect of varying factors on their behavior. Thus, if two substances are brought together, we want to know if they will react spontaneously to form a desired end product, to what extent they will react, and how fast the reaction will take place. Thermodynamics will help us to a large extent since by its use we can study all possible equilibrium states of systems composed of a very large number of molecules. Since all such systems tend to move in the direction of a state of equilibrium or from states of less to states of greater stability, this science will give us very important information concerning the direction in which a given physical or chemical process *tends* to take place. On the other hand, thermodynamics tells us nothing regarding the rate at which such processes occur. For example, thermodynamics predicts that at ordinary room temperature the system, nitrogen and hydrogen, is unstable and that ammonia is stable. Consequently, it is possible to bring about the reaction of nitrogen and hydrogen at this temperature. However, these gases do not react spontaneously, and various means such as high pressure, a somewhat raised temperature, and the presence of a foreign solid substance, a catalyst, must be employed to bring about their union.

When we raise questions concerning rates of chemical reaction and rates of many physical processes such as diffusion with which the chemist has to deal, thermodynamics fails us and we seek a solution of our difficulties by the application of statistical mechanics, or the mechanics of systems composed of large collections of atoms, molecules and light waves. This vitally important subject of chemical kinetics is extraordinarily interesting although it is accompanied with very great experimental and theoretical difficulties. Here, we consider the effects of the number of collisions of molecules and the effects of the number of collisions of molecules with radiation upon the rate of reactions, and many problems of a similar nature. Further, as noted above, the effect of the presence of foreign bodies, catalysts, on reaction rates is a fascinating part of this general question. Our method of approach is the kinetic theory generalized, or statistical mechanics. We have only gone a short way towards the interpretation of this intricate subject.

The methods of thermodynamics and statistics are essential to our studies, and in one form or other will prove of great value for many years to come. In addition to these, however, we are all aware of the continual changes going on in the field of atomic physics, where we are witnesses to the development of micromechanics, the mechanics of the parts of the interiors of atoms. We look to this recent interpretation to give us some insight into many of our greatest difficulties, particularly in the field of chemical kinetics. It is the younger men, well versed in the newer quantum theory mechanics who are best calculated to give us the most interesting theoretical physical chemistry in the next two decades.

Now, no one man can be expected to be an expert in all of these subjects, nor can one university laboratory be expected to carry out experimental work in more than a few divisions of physical chemistry. On the other hand, we may be generally well informed concerning much of this, and specialized to such an extent as to carry on in one field of the subject. To this end, beside the fundamental training in physics and chemistry, a thorough knowledge of calculus and advanced calculus is rapidly

becoming essential. This need can be illustrated by a very simple example. Some of us and also the biologists are very interested in knowing and predicting the nature and properties of solutions of ordinary table salt in water. These solutions have freezing points, boiling points, vapor pressures, osmotic pressures, and certain cells containing them will produce electromotive forces. Thermodynamics shows us that all these properties are related and that from a determination of one of them we can calculate the others. Now, a salt solution conducts the electric current, and, therefore, contains charged particles. Indeed, it produces an electrostatic field which in a molal solution (58.5 grams in 1,000 grams of water) has a potential gradient of 10,000,000 volts per centimeter. The theoretical consideration of such a condition requires electrostatic field theory. Furthermore, the ions have a random motion, a thermal motion similar to the molecules of a gas. This consideration brings in statistics. The ions of different kinds have different electronic structure, and since their properties depend on this, a knowledge of their inner structure is necessary to discuss their behavior. This requires atomic theory. So we see that consideration of a simple salt solution involves a number of branches of physical science, indeed all which we have previously mentioned and more. These are the kinds of subjects we must know in order to follow the course of theoretical chemistry, whether we are experimentalists or theorists. If we devote our time to experimenting, then we must understand these subjects, and if we are so gifted as to be engaged in purely theoretical matters, then we must not only understand but must master these mathematical methods and be able to employ them with the greatest facility.

These few remarks sketch a very interesting history. We have outlined the development of theoretical chemistry from the time when simple multiplication and division were the mathematical requirements of the chemist to the present time when the physical chemist requires much the same training as the physicist. It is simply a matter of bringing the most powerful methods of physical science to a focus upon our problems whether they be those of gas reactions, reaction velocities, salt solutions, protein solutions, surface phenomena or what not. All this is the result of the development of the quantitative method which the age of Galileo, Kepler, and Newton gave to the world.

Majority of Yale Club Prizes in Sheff.

Of the thirteen prizes recently awarded by the New York Yale Club to members of the class of 1932 on a basis of work done during their Freshman year, seven of the recipients were members of the Scientific School. It is also worthy of note that the first and third prize-winners were Sheff. men. The first prize of one hundred and fifty dollars was awarded to Groome McCague Gamble, who prepared for Yale at Lewis and Clark High School in Spokane, and at the State College of Washington. His average grade during the year was 94.5 out of a possible hundred. Third prize of fifty dollars went to Carl Raymond Schneider of Windsor, whose average was 93. Charms for the highest averages over ninety were awarded to the following Sheff. men. Groome McCague Gamble, Seattle, Wash., L. Glowacki, New Haven, Conn., Samuel Daniel Kushlan, Bristol, Conn., Mario Scalera, Meriden, Conn., and Carl Raymond Schneider, Windsor, Conn. Fifty dollar prizes for the greatest improvement during the year were awarded to John Elmer Livak of Rutland, Vermont, and to Wayne Frank Comer of Bridgeport, Conn., both of whom are Sheff. men.

OUR CONTRIBUTORS

¶ *Archer Eben Knowlton, who discusses the relation of Electricity to Prosperity, received his degree of B.S. at Trinity in 1910, his M.S. there in 1912, and his E.E. from the Sheffield Scientific School in 1921. He was appointed instructor in Electrical Engineering in 1919 and became Assistant Professor in 1922. He is also Electrical Engineer for the Connecticut Public Utilities Commission.*

¶ *Charles F. Scott is the Chairman of the Electrical Engineering Department and Professor of Electrical Engineering. He writes on "The Significance of Electric Lighting". Professor Scott received his B.A. from Ohio State University in 1885, and he has been awarded honorary degrees by Pittsburgh, Stevens, and Yale. Before coming to Yale he was Consulting Engineer with Westinghouse. He has been a member of the Executive Committee of the American Engineering Council since 1921 and is a past president of the A. I. E. E.*

¶ *Mr. A. J. Ralph, who writes on Eli Whitney, was born in England, where he learned his trade of design of research equipment. He came to the United States in 1880, and has been associated with the General Electric and Westinghouse Electric Company. He has been a designer of apparatus for Yale for fourteen years. He is President of the Hamden Historical Society.*

¶ *Michael Ivanovitch Rostovtzeff, whose article on the Excavations in Dura appears in this issue, was born in Kieff, Russia. He received his Ph.D. from the University of Petersburg, and has received honorary degrees from Oxford and Leipzig. He came to Yale from the University of Wisconsin having previously lectured and taught in the University of Petersburg and Oxford. At Yale he is Sterling Professor of Ancient History and Classical Archeology. He has written several books, and is a member of numerous honorary societies. In 1927 he was elected to the French Academy.*

¶ *Doctor Henry Margenau, who writes on "The Metaphysics of Modern Physics", is a citizen of Germany and graduated from Lehrer-seminar in that country in 1921. He received his A. B. from Midland College in Nebraska in 1924, and his M. S. from the University of Nebraska in 1926. He has been Graduate Assistant and Instructor in Physics there, and came to Yale as Instructor in Physics in 1928. He received his Ph.D. from Yale in 1929, and is at present studying in Germany.*

¶ *Professor H. S. Harned, whose article on Chemistry and the Quantitative Method appears in this issue is a graduate of the University of Pennsylvania, receiving his A. B. in 1909. He later received a B. S. and Ph.D. from the same university, and became Instructor in Physical Chemistry there in 1913. He rose to Professorship in this subject, and became Professor of Physical Chemistry at Yale in 1928.*

¶ *Mr. William F. Parish, who contributes the article "The Lubrication of Modern Machinery", organized the first lubrication-engineering departments of the Vacuum Oil Company in this country in 1901 and later organized and operated similar departments for this company abroad. After 1911 he organized similar work for The Texas Company. During the World War he was Chief of the Lubrication Department of the Air Service, U. S. Army. At present Mr. Parish is a consulting lubrication engineer interested in advanced problems in petroleum technology and is the author of many papers which have been presented before engineering societies.*

The Lubrication of Modern Machinery

The History of Machine Lubrication Methods and a New Source of Motor Lubricants.

By William F. Parish

IF primitive machines were lubricated at all, they were oiled or greased by hand. The early machines, classed as primitive, were roughly made so far as the bearings are concerned. Their parts were mostly made of wood; when made of metal, it was wrought by hand and was not machined. The parts did not need to fit accurately, and so much lost motion always existed on account of the shrinkage and wear of the material, warpage, and the swelling or shrinkage of all parts, that there was no reason for constructing the bearing surfaces otherwise than to make

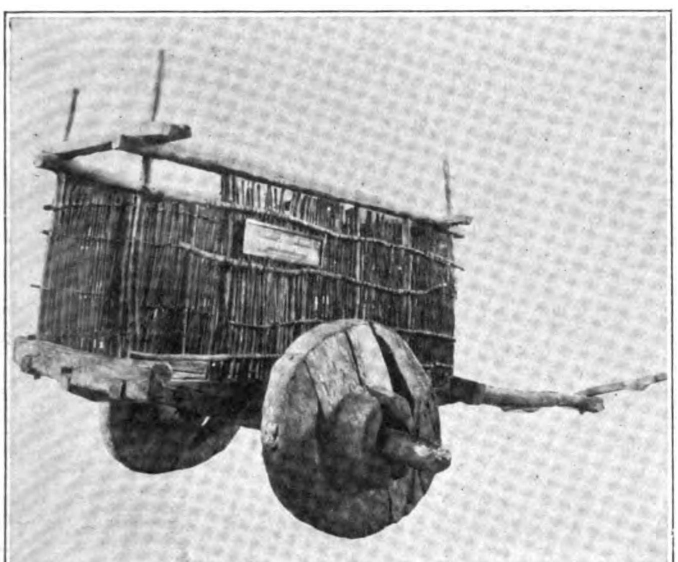


Fig. 1. The oldest vehicle in the Western Hemisphere, a Mexican oxcart, now in the U. S. National Museum, through whose courtesy this picture is published. This illustrates the most primitive form of bearing—wooden wheel and wooden axle.

them properly related to the other parts. The gum producing fats of animals, or the vegetable oils, were entirely suitable as lubricants for such machines, however they might be applied.

The lubricant, the machine and the hand method of application were properly balanced, and the operation of the machine proceeded about as was expected.

Intermittent Lubrication by Hand

When a lubricant of any kind is applied by hand to a bearing surface, it is always either a feast or a famine even when the greatest care is taken to apply the oil regularly. When first applied the supply is always too profuse even though the instructions may read "use only a few drops"; and since in practice, much more oil is used than is needed, most of it runs through the bearing, drips to the floor and is lost. The gradual leakage of the excess oil causes the bearing surfaces to become increasingly drier until, as a rule, before they are next flooded, they are devoid of lubricant, the metal surfaces are making contact and causing wear. The bearings of some machines give audible notice to the attendant that more lubricant is needed. In case the machine is operated by the attendant's effort, the need for lubrication will be indicated by the increasing friction of the parts as they become dry; to lessen this drag and make his work easier, he will then apply more oil.

Lubrication by hand is intermittent lubrication. It is inefficient at best because continuous operation depends upon profuse applications of lubricant, consequent wastage, and the danger that the needed lubricant will not always be applied just before the metal surfaces become dry and strike together. Generally any machine constructed so that it depends upon some human being to oil its numerous bearings unfailingly at frequent and regular intervals for an indefinite period is doomed by its designer to a short life, filled with adjustments, troubles and repairs.

The early engineers who built the first successful machine tools, machinery and engines succeeded in producing mechanical aids to nearly every operation. They harnessed sufficient water, wind, animal or low "pressure" steam power to secure continuous operation of the production machines on a scale greater than ever before. Practically all the mechanical difficulties in maintaining continuous operation of these early machines were chargeable to poor lubrication. Burned out bearings and the consequent repairs and delays to operation were due to the quality of the lubricants as well as to the method of applying them. This led to the celebrated research work of Beauchamp

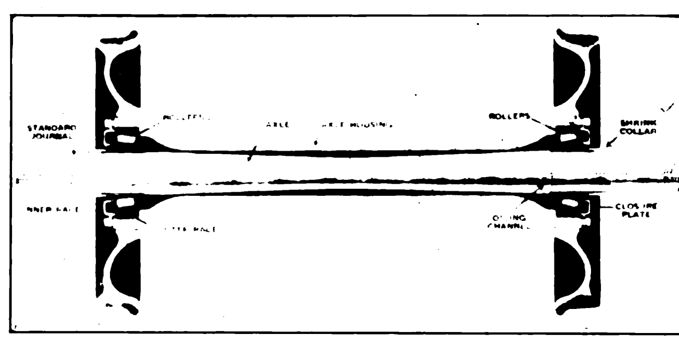


Fig. 2. Modern lubricated railroad roller bearing. Courtesy of American Steel Foundries .Co., Chicago, Illinois.

Tower as reported in the Transactions of the Institute of Mechanical Engineers in 1883.

Evolution of Machines and Lubrication

The work of Beauchamp Tower and the circumstances that made it necessary indicated much more than a problem of lubrication and the solution. It establishes in the technical record the fact that contemporary engineering had advanced beyond the previous development and that there was a general unbalance between the essential factors, that is, the machine, the lubricant and the method of applying it. The lubricants then available had been in continuous use by those who had equipment which required lubrication of some sort ever since the first wheel squeaked on its wooden axle. The fat of animals and the oils extracted from plants are food materials and could be prepared by almost anyone. These lubricants, so suitable to the mechanical condition of the entire period of their successful

use, had not changed in any way to bring about the problems which led to Tower's experiments. The development of the machine itself threw the mechanical proposition out of balance. The available lubricants had about reached their limit of endurance.

Tower's work showed that the problem of application of lubricant was involved. He determined that the most unsatisfactory performance of a bearing followed the application of any lubricant by hand. When the lubricant was placed in a reservoir and fed to the bearing surfaces by a wick so that

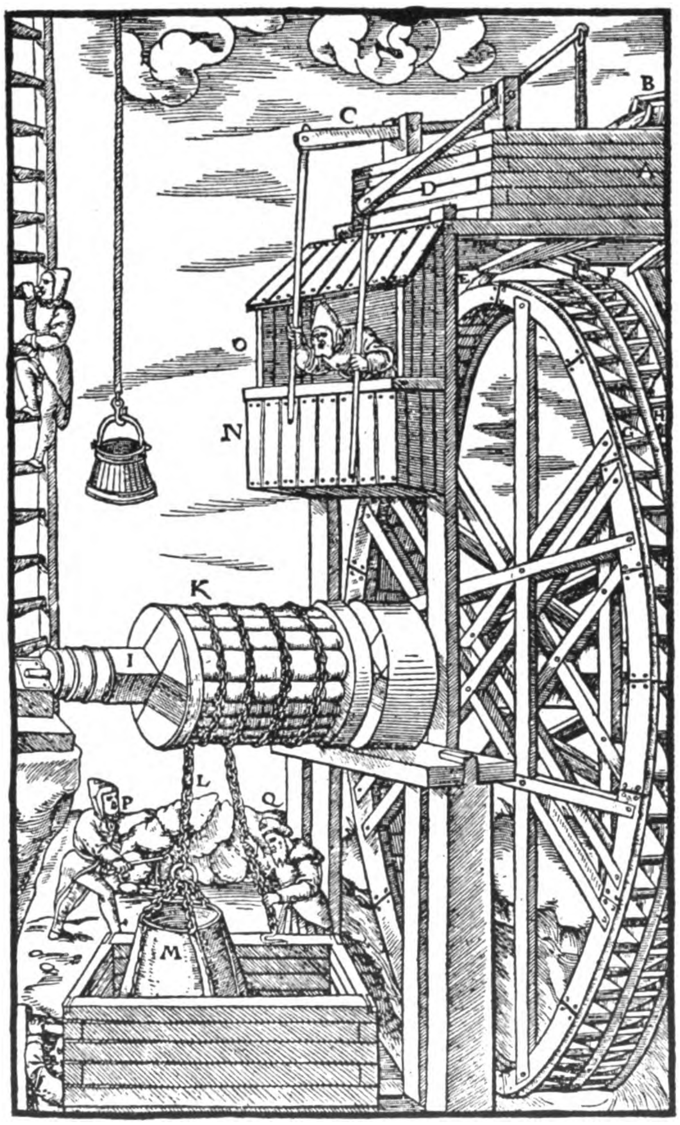


*Fig. 3. Reversing Engine for Mine Shaft, 16th Century. From Georgius Agricola's De Re Metallica, 1556 A. D. This shows the open shaft end and the lower bearing suitable for packing with side of pork or beef tallow.**

the working oil film would be maintained continuously, a great improvement resulted. The greatest improvement was evident when the bearing was completely bathed by lubricant. When this method of bath lubrication was used, only about one-tenth of the power was needed to move a bearing as when it was oiled intermittently by hand.

*(From Translation from the original Latin by Mr. and Mrs. Herbert Hoover, 1912.)

Power Savings

The experiments of Tower proved that considerable differences existed between the amounts of friction of a machine, according to the different kinds of lubricant used. The friction with sperm oil when using the bath method of application was taken as being 1; with rape oil, 1.06; mineral oil, 1.29; lard oil, 1.35; olive oil, 1.35; and mineral grease, 2.17. These figures indicate the fluidity of the different lubricants at the time they were used in the experiments. Within certain limits, the degree of power absorption resulting from the use of different lubricants on a test bearing closely follows the degree of viscosity of the oil while at work; the least amount of friction is nearly always associated with the thinnest lubricant. Tower's work indicated a method that was used later by Thurston and his contemporaries in their experiments with the mineral lubricants. It led later to the general methods adopted by the earliest lubrication

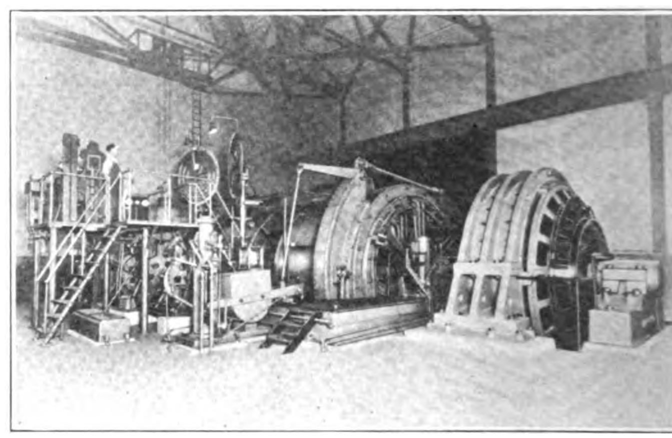


Fig. 4. Modern electricity operated mine hoist with gravity forced feed lubrication. Courtesy of Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

engineers in applying lubricants to various classes of machinery. Then it was discovered that lubricants which possess high viscosity, or great "body", cause an excess of power to be needed for the operation of machinery; by using oils having a lighter body and the same methods of application, savings of from 10 to 40 per cent of the power required to operate line shafting and machines of all kinds were found practicable.

Circulating Lubrication Systems

The first improvement in lubricant application following Tower's experiments was the adoption of the bath lubricated spindle in the cotton mills. Formerly the spindle was seated in a shallow footstep which had to be oiled daily. The supporting bearing, somewhat farther up the spindle required more frequent oiling because the bearing was vertical and the oil soon ran out. Enclosing the bearings of the spindle in a bath consisting of part of an ounce of light oil that was replenished once every two weeks effected a very great saving in oil and labor. This also improved the cleanliness of the machines, the manufactured material, the spinning room and the operators. The fire hazard was reduced and the health of the operators improved. The form of the bearing allowed the lightest and most suitable oil to be used, held it in place and dissipated the heat from a large surface. It was thus possible to use oils that saved from 10 to 20 per cent of the power formerly required to operate the types of spindle which did the same amount of work.

The next general improvement was in the method of applying lubricant to the hangers of line shafts and to the bearings of

production machinery. Ring, chain, and collar lubricators were adopted for this work. These had almost as great an effect on the general economy of the mills as did the change in the method of lubricating the textile spindles. Formerly, line shafting needed to be lubricated several times daily by hand. The introduction of the ring oiling bearing, with its revolving rings dipping into a reservoir of oil, made it possible to use a much better and more suitable oil, and one filling of oil would last for several months. This form of bearing was adopted for all electric generators and motors and in general has done much toward advancing the usefulness of all machinery to which it can be attached.

The next general advance in the science of lubrication was concerned with steam engines and large production machines, the bearings of which always had been lubricated by hand. Formerly a handy oil can was used by the attendant to squirt oil on a bearing whenever noisy operation seemed to be due to

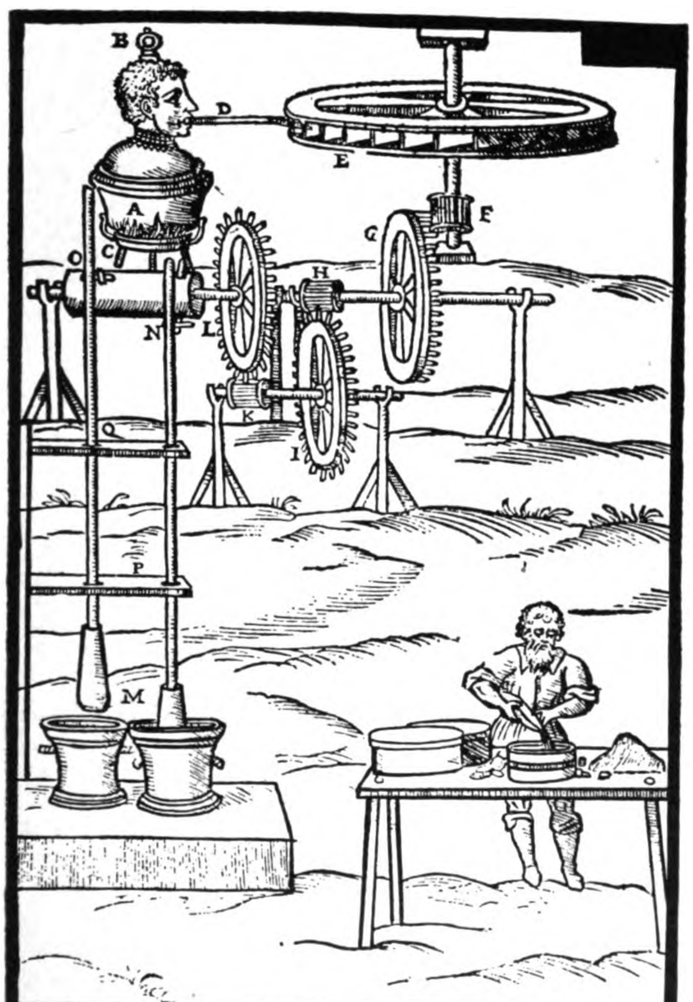


Fig. 5. Branca steam turbine from his book printed in 1629 A. D., indicating the original form of line shafting bearings which originated from the forked branch of a tree.

lack of lubrication. In the case of large steam engines, regular oilers were employed and every bearing received attention at regular intervals. The oiler made his rounds several times an hour; he felt the temperature of each bearing and squirted additional oil through the oil hole of the bearing caps or directly on to the connecting rod guides.

When "bottle oilers" were developed, the attention of the oiler to bearings so fitted could be reduced somewhat. Later sight feed adjustable oilers for the various bearings were devised; these were afterward connected by filling pipes with a reservoir which held several gallons of oil. The oil that had dripped out of the bearings was caught in pans placed under the engine. A tank or empty barrel, equipped with layers of felt or cheese-cloth was

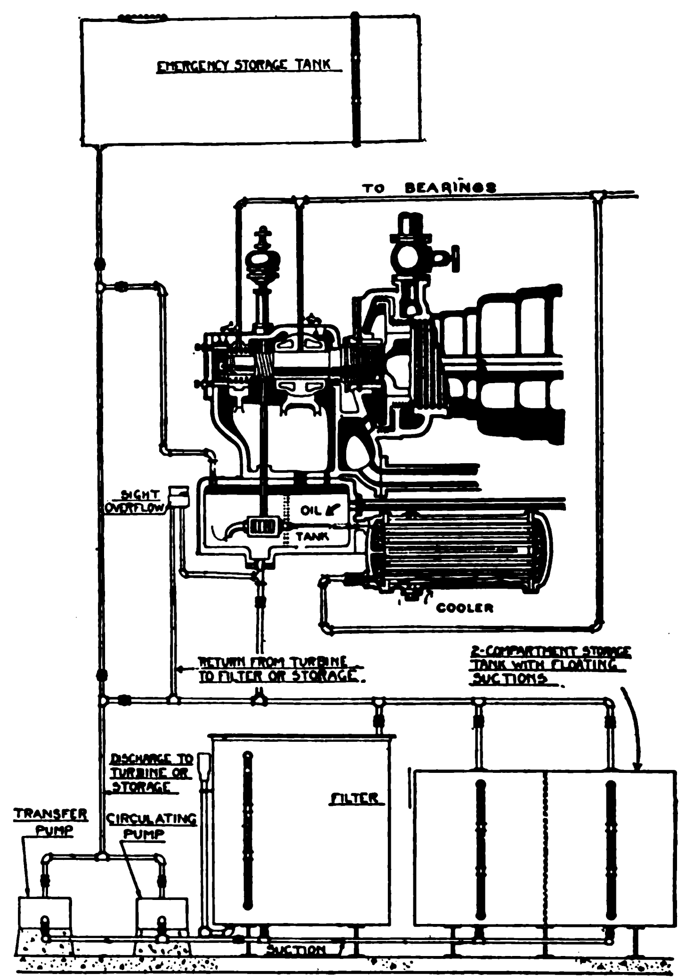
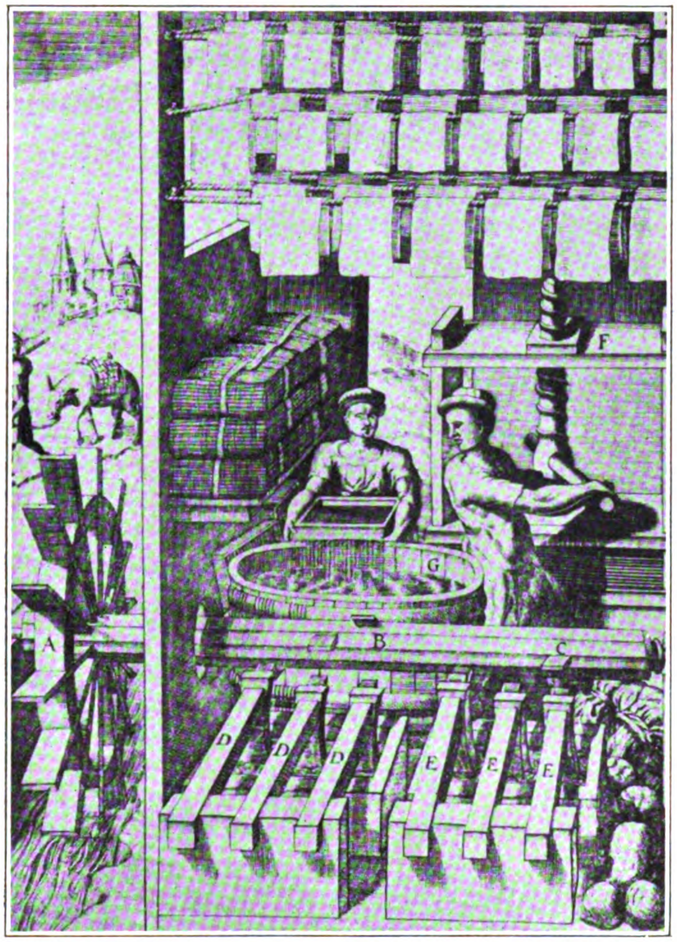


Fig. 6. Modern circulating oil system attached to a steam turbine. Courtesy of S. F. Bowser Co., Inc.

used as a home-made filter. The strained oil was then used to lubricate the parts of the engine that never gave trouble. As filters were improved, the circulating systems were developed so that the oil passing through the bearings and into the pans or sump was pumped into the top of the filter and flowed by gravity back into the bearings.

During this gradual development in the science of applying lubricants, the first commercial steam turbines were being built by many companies throughout the world. These early steam turbines had more effect on the complete development of the circulating system of oiling than had any other class of machine, because they produced conditions that had unusually severe effects upon the lubricant. They also introduced the first serious contamination problems connected with the circulation method of lubrication. The first turbines of the horizontal type were provided with small reservoirs in the base of the machine that were almost an afterthought. A force-feed pump took the

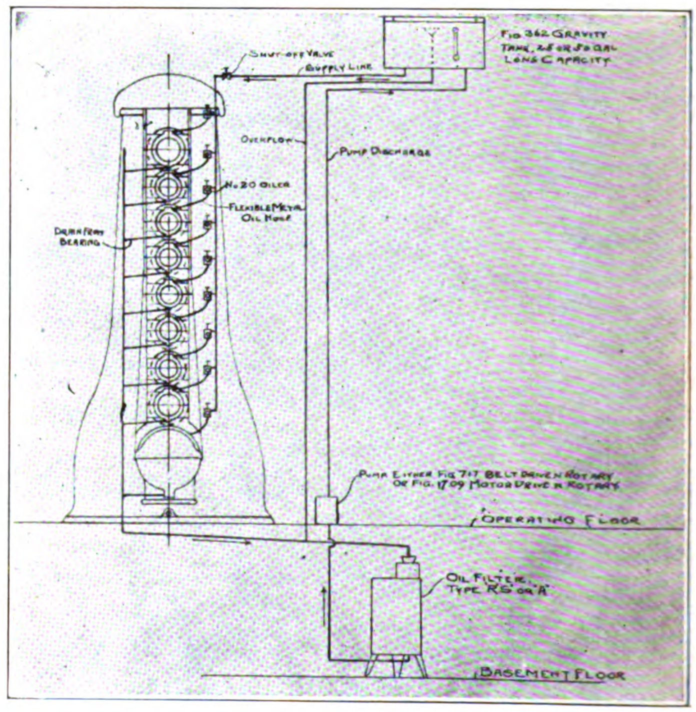
relatively small amount of oil and circulated it furiously through the outboard bearing and the two main bearings, which, in this machine, were very hot as a natural result of being close to the steam entrance and to the exhaust outlet of the turbine. The steam leaked into the bearings, and condensed, and the water mingled with the lubricating oil. The condensed water carried traces of all the salts and boiler compounds from the steam boiler. The oil and water formed an emulsion due to the constant churning, to the air that was present, and to the mixture heating in the bearing and cooling in the tank. These emulsions sometimes formed solid deposits that were referred to as petroleum soap, which effectively stopped up the stainers, held the oil away from the pump suction and were the indirect cause of bearing failure because no oil entered the circulation system. A bearing failure in a turbine generally is caused by the melting of the bearing metal; this allows the shaft to settle and the consequent engagement of the turbine blades results in a complete wreck before the machine can be shut down. Such wrecks were common enough in the early stages of turbine development to make it necessary to carry a complete spare turbine in stock in every station; but this custom is no longer necessary because the lubrication of these machines is so nearly perfect due to the improvements in both lubricants and systems of application. The centrifuges, filters, settling tanks, heaters, coolers, and other important auxiliary equipment generally occupying more space than does the turbine itself.



Bocklern's, Theatrum Machinarum, A. D. 1662. Early paper making showing the open bearings for the shaft which could be packed with tallow, and hand-press, the worm of which could be lubricated with vegetable oil.

Automotive Engines

The lubrication of the earliest automotive engines was by means of small manifold oilers developed for the larger steam engines and some of the production machines. The oil was piped into the various bearings and thence ran out on to the ground. Later, the engines were enclosed and the oil that drained from the bearings gathered in the lower part of the crankcase; it was splashed around by the lower ends of the connecting-rod, which thus effected lubrication. This practice was in vogue twenty-five (25) years ago in lubricating high-speed steam engines of both the vertical and the horizontal types, but it has since been discontinued largely on account of problems of oil contamination. Lubrication difficulties impossible to correct eliminated these types of steam engine; the cost of repairs caused by inadequate lubrication were so excessive that the engines could not survive



Stack of calenders for modern paper making machinery showing circulating system for lubrication of the roll ends. Courtesy of Farrel-Birmingham Co., Ansonia, Conn.

against types that could be lubricated better. Lubrication of the automotive type of engine was continued with splash systems until the force-feed systems were introduced; many engines then were run with a combination of splash and force-feed, and this is the present method.

Automotive Fuel

During the early years of the automobile, and until 1914, the gasoline used for fuel was in effect a by-product of the oil refineries which operated mainly to produce kerosene and lubricating oils. The greatly increased use of automotive equipment created demands for a greater quantity of motor fuel than

(Continued on page 32)

Electric Light's Fiftieth Anniversary

Edison's Invention of the Incandescent Lamp Marked the Launching of the Electrical Era.

By Professor Archer E. Knowlton

In many respects the enormous electrical industry that now serves industry and mankind can be said to have hung on a veritable thread in its early days. That thread was the lamp filament which Thomas A. Edison on October 21, 1879 announced that he had developed to practical perfection. The industry that has grown out of that persistent and courageous research has social and industrial consequences that most of us sense. But it may be well to take ourselves back fifty years and visualize the status of the electrical and lighting arts of that period.

The Arc-Light Era.

Edison was not the first to obtain light from electrical sources. Sir Humphrey Davy in 1802 had produced an arc by separating two carbons whose contact had closed the circuit carrying a current originating in the electric pile devised by Volta in 1800. By 1808 Davy had accumulated 2000 of Volta's cells and two years later gave a demonstration of electric arc lighting before the Royal Institution. Years elapsed before we note any progress toward commercial adaptions of the new phenomenon. Patents were granted in England, to Wright in 1845 and Staite in 1846, for steps that moved the light toward the practicality of our modern arcs. Jablochkov lighted the Paris boulevards with alternating current arcs in 1876. Niagara Falls on July 4, 1879 attracted excursionists to see an extensive illumination spectacle; the arcs were too feeble to do justice to the Falls so they were directed on a fountain in the park. Meanwhile French and British lighthouses had been equipped with arc lights. William Wallace, Edward Weston, Charles F. Brush, Elihu Thomson and Edwin J. Houston were engaged in perfecting the arc lights as well as the generators and the distribution systems to supply them.

THE ELECTRIC LIGHT makes possible the modern home, industry, transportation, mining, theaters, automobiles, aviation and a hundred other every-day activities. Only by considering this can we realize the place that electric lighting has taken in its step-by-step progress during the past 50 years. Professor Knowlton gives here, in connection with the fiftieth anniversary of the incandescent light, a summary of its development and of its significance in our civilization.

At work in the minds of many of these explorers was the ambition to discover a means of obtaining electric lighting in smaller units than the arc scheme permitted. The dream of lighting homes as well as streets was the urge. But the obstacle was the inherent constant-current characteristic as well as the concentrated brilliancy and electrode-replacement limitation of the arc. The natural drift of research was toward the incandescence of solid conductors rather than the luminescence of arc vapors.

The Early Incandescence Trials.

Edison was not the first to obtain light from rods, filaments or wires heated to incandescence by electric current. Sir William Grove, of non-polarizing cell fame, in 1840 heated a platinum wire to incandescence. DeMoleyns a year later got the first patent on an incandescent lamp composed of charcoal between flat coils in an exhausted bulb,—impractical because the bulb blackened quickly. Starr in America in 1845 had little more success with a carbon rod in the evacuated space at the top of a barometric column. The next fifteen years saw efforts by several others including Professor Farmer at Newport to devise a feasible incandescent lamp. Lodyguine in 1872 lighted a Russian dockyard with 200 lamps that were based on the incandescence of graphite in a nitrogen atmosphere but they had only a 12-hour life. During the next few years reasonably successful incandescent lamps were developed but they had short, heavy (low resistance) filaments which rendered them suitable only for 10 to 20 or 30 volts.

Edison Enters the Electrical Arena.

Edison entered telegraphy as an apprentice in 1862 and when he was twenty-one (1868) invented and patented a vote recorder. Next he improved the stock ticker and before long had invented a universal printer for the telegraph. The duplex and quadruplex telegraph followed between 1872-1875. It was late in the year 1877 that he shifted his attack from the field of communication to that of electric lighting. He became obsessed with the same idea that was urging many other investigators,—an electric light that would replace gas-lighting of homes, burn brightly, consume little current and be independent of all other lamps in the same circuit. The arc lamp could satisfy only one of these desiderata and that not wisely, but too well,—it was too bright. His other inventions had given him ample funds and he set to work with some fifty assistants.

One of the early attempts was a long platinum filament on a clay spool provided with a thermostatic circuit-opening scheme to prevent the melting of the platinum wire. It was coated with zirconium oxide to prevent oxidation but failed because the oxide became conducting at the high temperature and short-circuited the filament. One valuable point was learned from these experiments and that was the occlusion of gas by the platinum. To place the platinum in an evacuated tube appeared prohibitively expensive and Edison reverted to carbon in spite of its failure at the hands of his predecessors. His goal was very definitely a high-resistance filament longer and more slender than anyone before him would admit was feasible. After sever-

al trials a piece of cotton sewing thread was carbonized. One of the frail filaments was finally encased in a glass bulb evacuated by the recently devised Geissler and Sprengel mercury air pumps. The occluded gas required eight additional hours of pumping to remove it after a weak current through the filament started to expel it. Finally the lamp was ready for trial.

It was on October 21, 1879 that the lamp was subjected to its test of adequacy. Perhaps it is too much to say that the electric light and power industry of the future hung on that thread. Edison's zeal, persistence and intellectual courage would have impelled him to new efforts if that crucial test had failed. It did not fail because the forty sleepless hours that the group watched its brilliance was enough to spell success. Some $40,000 was spent in preparation for this experiment and $100,000 more was applied to the perfection of a commercially applicable product. The world was scoured for grasses and fibers to form the most advantageous filament to supplant the fragile sewing thread product. Thousands of experiments were conducted with hundreds of carbonized materials. One test was even made of red hairs from the beard of the same J. U. Mackenzie, the railroad station agent who had rewarded Edison by taking him on as telegrapher's apprentice at fifteen in return for

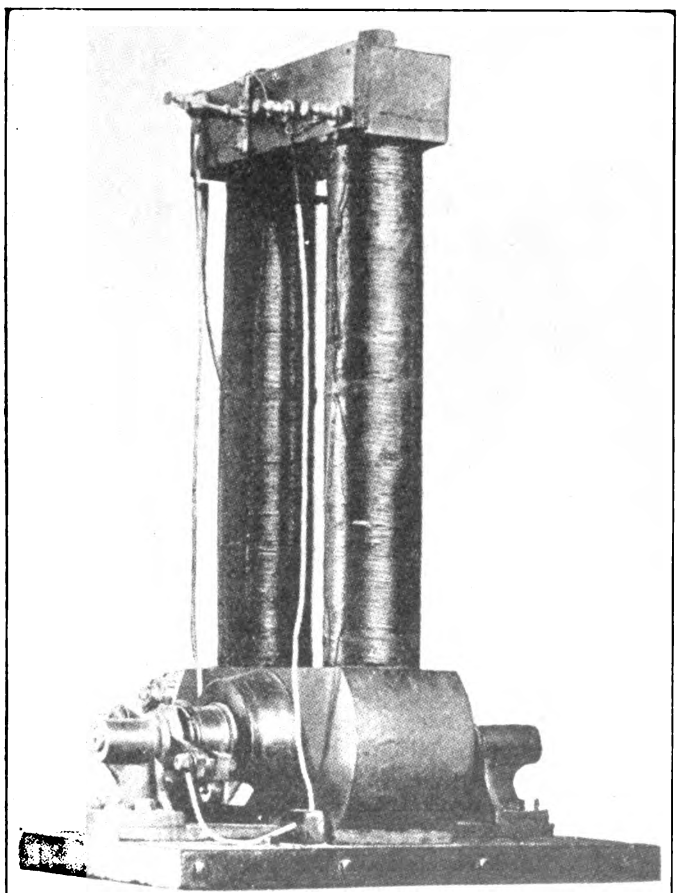


Fig. 1. "Edison Dynamo of 1879". Installed on the Steamship Columbia to supply the power for the first commercial installation of the Edison lamps.

his snatching Mackenzie's small boy from the path of a rapidly rolling box-car.

No finer example exists of the tenacity, perseverance and exhaustiveness of industrial research than Edison's determination to solve the problem of the incandescent lamp. Others manifestly lacked his intellectual vigor and courage. Many of them ridiculed his stand for a higher resistance filament which would simultaneously effect the "subdivision of light" which they held impossible and the solution of distribution over distances of several blocks, at least. Edison's lamp was designed for operation at 100 or more volts, the earlier lamps were restricted to lower voltages that Edison knew would not conform to his program of

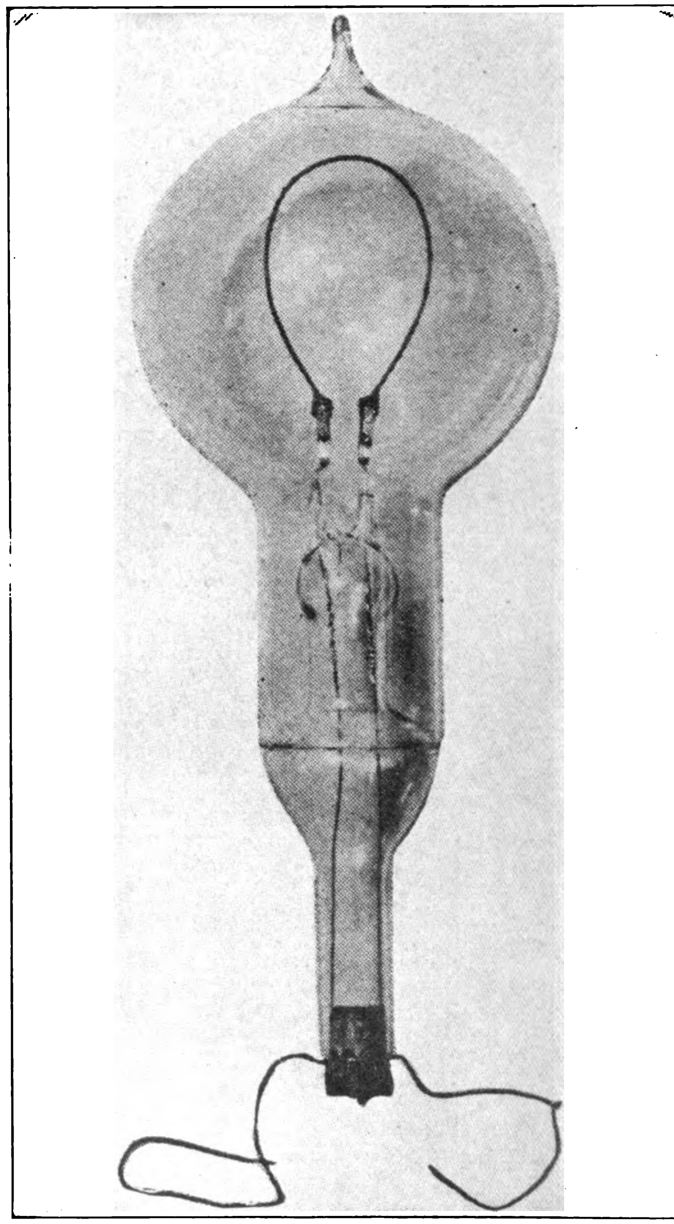


Fig. 2. "Model of Edison's First Successful Lamp of October 21, 1879".

an extended distribution system. No less an authority than Professor Sylvanus P. Thompson (in 1883) "I think that any system of electric lighting depending on incandescence will utterly fail from an economic point of view and will be the more uneconomic the more the light is subdivided". Many of the notables of earlier days had been subjected to similar ridicule. Even Ohm had been driven from his teaching position in the Cologne High School in 1825 for having the audacity to expound the law which is the fundamental of all electrical circuit theory and had to wait years for the recognition that came with the award of a medal by the Royal Society of London.

(Continued on page 42)

The Significance of Electric Lighting

At First a Luxury, the Electric Light has become Essential to Efficiency, Safety, Comfort and Happiness.

By Professor Charles F. Scott

AUSTIN C. DUNHAM was an electrical pioneer who developed the Hartford Electric Light Co. from a small beginning to a substantial and progressive organization. He enjoyed introducing new things, storage batteries, underground cables, the first aluminum transmission line, the first three-phase commercial transmission, the initial "tub system" for supplying constant current to alternating arc lamps, the first three-wire rotary converter, the first large steam turbine. He wrote a number of reminiscent pages "to give permanence to a state of society that is fast passing away." Mr. Dunham was born in 1834, a few years after the discovery of electromagnetic induction and a decade before Morse's telegraph. Mr. Dunham reminisces upon conditions of the early days. He relates: "Two things greatly influenced the habits and character of the New England people. The first influence was the very slow progress made in the means of locomotion. Most of the people lived and had their being within a very limited area, where their habits were formed and their peculiar mental character developed and influenced by the small circles in which they lived and by the subjects mostly of a religious doctrinal character which they habitually discussed.

"The second influence was artificial light, which came slowly into use and which molded the character of both country and city people. 'Early to bed and early to rise makes a man healthy, wealthy and wise' had a physical origin as well as a moral instruction. Dipped candles favored going to bed between 8 o'clock and 9 and getting a good long day by rising at dawn. A great industry, the hunting of the whale, created ship building and developed a race of hardy sailors who made long voyages in perilous seas of the north.

"It is difficult for us at this time to realize what change was made in the life of men by these two things—the practical shortening of the distance from any one point in the world to another and the great increase in time effected by an unlimited supply of light. The limit of Time and Space seemed to be moving on toward abolition."

Lighting in the Remote Past.

Mr. Dunham mentions the candle and by inference the whale-oil lamp. Candles and olive oil for lamps are mentioned in the early chapters of the Bible. Little clay lamps are found in the ruins of cities which flourished 8,000 years ago. Later lamps of stone or metal retained a common shape which provided an open or closed vessel for oil, a trough at one end for a wick and a handle at the other end.

The "Betty" lamps, the small iron lamps with open wicks, brought over in the *Mayflower,* were similar in principle and type to the lamps found in the early excavations. The ill-smelling oil burned by the Pilgrim fathers was not unlike that of ancient days, as a Greek writer remarks that "one could not enjoy the good things of the table until his indulgence in wine had made him indifferent to the stench of the smoking lamps." (The incandescent lamp by its simple purity has paved the way for the Volstead era). Fires, torches, pine knots, rushes saturated with grease or tallow, candles and smoking, flickering lamps—such were the sources of artificial illumination for unrecorded centuries without important change until within a half dozen generations. A simple modification was a tube for the wick. Lamps of tin or pewter were made with the wick through a tube in the top. Ben Franklin at the age of ten worked in the Boston shop of his father, a tallow chandler. Ben cut wicks. Later on he observed that the wicks needed frequent attention as they became covered with hard carbon or soot. The young illuminating engineer surmised that two wicks would cause a stronger current of air, and his experiments proved that he was right. Invention followed rapidly, and in the early decades of the last century several hundred United States patents were issued for whale-oil lamps. Whaling was the principal industry of New England for 150 years. Then, following the discovery and development of mineral oil, kerosene in the '50s began to take the place of vegetable and animal oils.

Gas lighting, the pioneer public utility, limited at first to the centers of larger cities, had its beginning in the early decades of the last century, but was not generally used in residences until after the middle of the century. The flat open flame was almost universally used.

Lighting 50 Years Ago.

The log fire in the fireplace, the candle and the flickering, smoky lamp were the principal sources of artificial light until a little over a century ago. (Matches for general use, it may be remarked, appeared just 100 years ago.) These improved burners and lamp chimneys and kerosene as well as gas gave improved illumination to the favored few, and slowly to the general masses. My father, born in 1840, saw a lamp chimney for the first time when he was 17 years old. That was just about the beginning of the use of kerosene, or "coal oil" as it was called in some places.

About 1880 the open gas flame, the kerosene lamp, usually with flat wicks but sometimes with Argand burners, and candles, largely in country homes, were the principal sources of light.

Then came electricity. First the arc lamp. The arc exhibited in 1808 by Sir Humphry Davy was produced by a voltaic battery (Volta's battery, not yet ten years old) of 2,000 cells. It waited two-thirds of a century for a dynamo which could supply direct current. The arc lamp created illumination of a new order—it was nominally 2,000 cp., 2,000 times the old-time candle and more than a hundredfold greater than the common gas jet. No wonder that the subdivision of the electric light into small units was an outstanding problem. Early in 1879 President Henry Morton of Stevens Institute said, "It is only by turning our eyes to the yet undeveloped possibilities of the future that we are able to see the electric light as a successful substitute for gas and other methods of illumination."

Sir William Thomson (Lord Kelvin) about this time, referring to the Jablochkoff candle, a sort of miniature arc between the ends of two parallel strips of carbon separated by an insulating substance that burned away, said: "I believe that is the most advanced subdivision of the electric light which we now have." He added, "I think with proper mirrors, lenses, prisms and screens it could be economically used throughout a house at present." But he added, "there is a large margin for future development."

Professor Tyndall said early in 1879: "Knowing something of the intricacy of the practical problem, I should certainly prefer seeing it in Mr. Edison's hands to having it in mine. And yet it is Faraday's spark (arc) which now shines upon our coasts (lighthouses) and promises to illumine our streets, halls, quays, squares, warehouses and *perhaps*, at no distant day, *our homes.*"

The Edison Lamp.

October 21, 1879, is celebrated as the birthday of the Edison lamp. Just two months later the New York *Herald* in its description of the newly proposed Edison system of incandescent lighting says: "The probable system to be adopted is the locating of a central station in large cities in such a manner that each station will supply about an area of one-third of a mile. In each station there will be, it is contemplated, one or two engines of immense power which will drive several generating machines, each generating machine supplying about 50 lamps." It is impressive to learn that right at the beginning it was proposed to do things on a scale which required immense power. The lamps contemplated were of the 16-cp. size.

In an interview a few days later one of the most eminent of the scientific professors of the time commented upon the difficulties involved in the new venture. He said: "All attempts up to the present lamp in this direction are acknowledged to be failures and, as I have pointed out, there does not seem to be any novelty such as would authorize us to hope for a better success in the present one. The next difficulty is in the economical production of small lights by electricity. Up to the present time, and including Mr. Edison's latest experiments, it appears that this involves an immense loss of efficiency. Next comes the difficulty of distributing on any large scale the immense electric currents which would be needed and to provide for their equal action at different points under varying conditions of the number of lamps used."

In fact, the engine, the generator and the circuit had to be developed as well as the lamp. Each year of the past half century has recorded some forward step in excellence or size of the prime mover and generating equipment. The meager area served by the initial station was slightly increased by the feeder-main expedient and by the Edison three-wire system. Later on, however, transmission distances were enormously increased by the use of the alternating-current high-voltage system, so that the area which may be served by a station has been increased from a third of a mile to a third of the nation.

For twenty-five years the two carbon lamps, the arc lamp with carbon electrodes and the incandescent lamp with carbon filament continued without notable change. Arc lamps were "inclosed" in a sort of little lamp chimney which retarded the burning away of the carbons but somewhat reduced the light. Incandescent lamps improved slightly in quality, but relatively very few were other than of the 16-cp. class. Generally speaking, there was no lighting unit between the small incandescent lamp and the intense arc lamp.

Then in the early years of the new century came the Nernst lamp with its little exposed inch-long rods of rare-earth oxides, emitting 50 cp. of very white light. The high intrinsic brilliancy introduced new problems of protection, reflection and diffusion that led to the beginning of modern illuminating engineering.

About the same time appeared the Cooper-Hewitt mercury-vapor lamp with its long tube of soft blue light, admirably suited for certain uses, but unsatisfactory for others as it distorts colors. Simultaneously came the flaming arc lamps, in which the luminosity was greatly increased by the addition of certain chemicals.

In the luminants of all the preceding centuries pine knots, candles, oil, gas, incandescent and arc lamp carbon had been the light-giving element; then in a few years came three lamps with other elements. And soon there followed metal filament lamps—tantalum and osmium quickly superseded by tungsten.

The Tungsten Lamp.

Tungsten lamps give several times as much light as carbon lamps for the same current; they give a whiter light, they can be made of any size, from a fraction to many thousand candle-power, their light in quality, quantity and efficiency rivals that of the arc lamp and they are far simpler in construction and require no renewal of electrodes. Their filaments may be concentrated, approximating a luminous point.

The whole lighting scene changed with the advent of new units giving greater volume of light at high intrinsic brilliancy.

Residence Lighting.

It is estimated that the value of a dollar measured by the light it will purchase for the home has gone up a hundredfold in a century. And it is not unlikely that as a result the average home uses a hundred times the light from its numerous electric lamps that it once received from its few candles. The cost of electricity for the average residence for meter service as well as light is less than 7 cents a day, about equal to a street car fare and less than an ice cream soda.

The circuits which supplied lamps nurtured motors as well, which led the way to power service. By 1904 the carbon lamp showed a wonderful record of growth. Its enormous use was heralded as one of the triumphs of applied science and modern manufacturing; in fact, an incandescent lamp could be bought for the price of a simple lamp chimney. But in the field of illumination it could do little more than the equivalent of a gas jet. Then came the larger units and the cheaper light of the tungsten lamp, qualities which were augmented with the advent of the gas-filled lamp. There was opportunity and necessity for directing and controlling light after it was produced; formerly the concern of inventor and engineer had ended with the lamp itself. New methods and new uses appeared, such as indirect lighting and semi-indirect lighting of interiors and floodlighting of exteriors. In a decade or so the little carbon lamp and the arc lamp had retired from supremacy to meager use. The tungsten lamp has continuously augmented the use of light for old and for new purposes. The problems of the past had been to generate and transmit the electricity and to produce the light; the new problem called for illuminating engineers to utilize the light after the energy had been generated and delivered.

(Continued on page 20)

The Yale-French Excavations at Dura

The Third Campaign in the Euphrates Valley is Uncovering Many Details of This Greco-Parthian City.

By PROFESSOR M. I. ROSTOVTZEFF

THE Syrian desert, grey and stony, falling off abruptly to the Euphrates' bed, black towers and walls surrounding a piece of desert between two deep ravines, and a powerful citadel overhanging the Euphrates—an oblong rectangle of high walls flanked on the right and on the left by two gates protected by a couple of towers each—this is Dura as you see it if you come down the Euphrates on its right bank from Deir ez Zor, the next important center of human life to the North of Dura. Inside of the walls, between the citadel and the main gate which leads into the city from the desert, lie the ruins of the buildings of the city of Dura. Those which have been excavated show the bare skeletons of their walls, with plaster-coating partly painted on them, those which have not are covered with a deep layer of sand and debris, not deep enough however to conceal the main architectural lines of each building which lies beneath the sand.

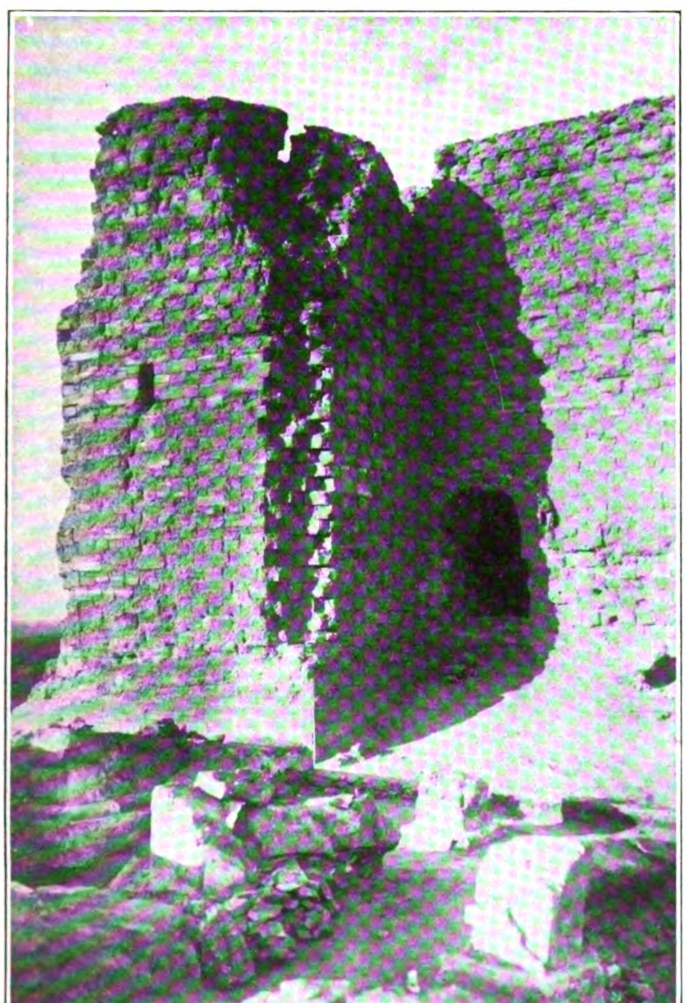


Fig. 1. The Citadel of the city of Dura. The north gate and the north tower. In the foreground are the remains of a Roman shrine dedicated to the cult of Roman emperors.

Once upon a time Dura was an important military and trading center of the Hellenistic, the Parthian and the Roman times, a strong fortress which protected important caravan roads—one coming from the South up the Euphrates from Seleukeia on the Tigris and from Babylon, another running from east to west from the cities of the Iranian plateau across the Assyrian lands to the Euphrates and crossing the Euphrates where the proud citadel of Dura protected the crossing from the attacks of the neighboring nomads. From the point of view of an historian Dura has had but a short life. Compare it with other caravan cities and great centers of civilization near the Syrian desert like Damascus and Aleppo which probably were important towns as early as in the IIId millennium B. C. and which still are the main cities of Syria. Compare the 5,000 years of their existence with the bare 600 years of existence of Dura, and you will realize the difference. And yet it is this very shortness of the life of Dura, the fact that Dura died young which makes the excavations of that site so interesting and so exciting. We have not constantly to guess to what period in the long life of the city one or the other monument discovered at Dura belongs: the choice at Dura is narrow—each object is either Hellenistic, i.e IIId to Ist century B. C., or Parthian, i.e. Ist century B. C. to IInd century A. D., or Roman, i.e. IInd century A. D. to IIId century A. D. You do not have to worry about the complicated stratification of the debris: two or three strata are met at Dura and not two scores of them, as e.g. in Susa in the Elamitic lands, or at Ur of the Chaldees. You are not forced in studying Dura to reconstruct, as in Babylon, from tiny remains the life of four millennia. Your study and your excavations give you an all round picture of the life of Dura in its short historical development.

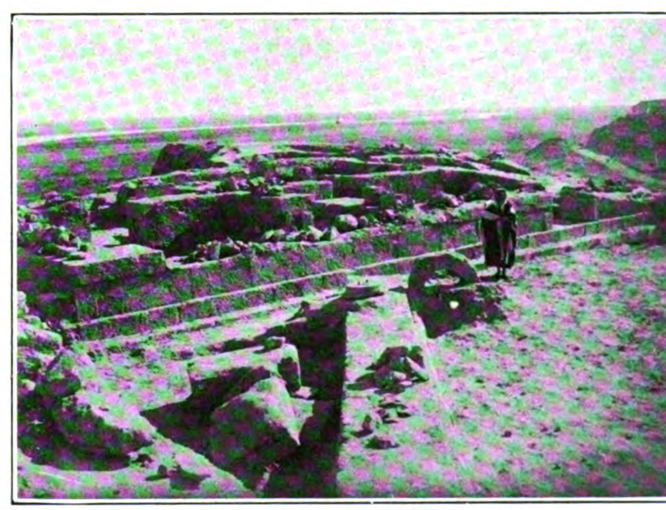


Fig. 2. Ruins of the palace of a Parthian governor of Dura on the top of a citadel. In the background is the Euphrates; in the foreground, a Bedouin sheikh.

You see Dura created by a general of one of the assistants of Alexander the Great—Seleucus, the King of Syria in about 280

B. C. Not very many remains exist of this early period of the life of the city. Dura of the Macedonian colonists seems to have occupied a restricted area on the river bank and to have been protected by two strong but small fortresses on the two sides of the Euphrates caravan road, of which one still exists—the so-called redoubt. The palmy days of Dura begin later. It was

Fig. 3. Skeleton of a strangled man found in the basement of the citadel. The man has no doubt been executed by strangulation.

the time when in the IInd century B. C. the Parthians had torn away from the Syrian Kings the valley of the middle Euphrates and the Euphrates caravan road with the military cities which protected it; among them Dura. Dura as a Parthian city, situated as it was on the Northwest frontier of the Empire and facing the strongest enemies of the Parthian Empire naturally developed into one of the most important fortresses of that Empire. A little later it became also an important trade and commerce center. This happened at the time when the rule of the Seleucid Kings in Syria was replaced by that of the Romans. The emperors of the early Roman Empire, now masters of Syria, after some vain efforts to conquer Parthia, decided to live in peace with the Parthians. Palmyra—the caravan-queen of the desert—was created by the common efforts of both the Parthians and the Romans, to serve as a neutral intermediary between Parthia and the Roman Empire. It was Dura, the Parthian fortress, which was now the natural protector of the roads which led from Parthia to Palmyra. No wonder that under such conditions Dura, which used to be in the Macedonian times a small fortress and a small though prosperous agricultural community, became a large commercial and military city, surrounded by strong walls and towers and protected by a powerful citadel along its river front.

It is natural that while the remains of the Macedonian city are scanty, those of the Parthian city are abundant. Some of them have been unearthed by Cumont in 1922 and 1923, some by the Yale expedition which took over the excavations of Cumont and of the French Academy and is carrying them on now in collaboration with the French Academy for the third season. The main lines of the city as we see them now were laid down by the Parthians. Its fortifications with the beautiful central triple gate which has been carefully excavated by Yale and with the elegant towers of various forms which have yielded to Cumont and to us priceless remains of the military life of the city and of its archives—documents on parchment and on papyrus so well

Fig. 4. Parthian soldier standing on the top of the head of (probably) a conquered enemy.

preserved under the thick layer of sand which accumulated along the wall and around the towers. Its citadel as described above; the plateau of the citadel and one of its gates have been carefully investigated by the Yale expedition. And finally its straight streets and blocks of houses through which passed the caravans which came from Palmyra and intended to reach the

Euphrates-road or which came from the East and the South and endeavored to reach Palmyra.

The aspect of the Parthian city becomes clearer every day. On the top of the citadel there arose a large and beautiful Parthian palace well protected against the attacks of the enemies and well provided with water, no doubt the fortified residence of the Parthian governors and of their body-guard. We have excavated this palace in our last campaign. The towers and gates of the citadel, partly excavated by Yale in 1928 and 1929, were the abode of some more soldiers. The basements of the towers served at the same time as prisons. In one of them we discovered in our last campaign a skeleton with a rope around its neck. No doubt a skeleton of one who had been executed here.

In the city the most conspicuous place was occupied by the large and rich temple of the city goddess—the Babylono-Parthian Nanaia, whom the Greeks called Artemis. The temple has been partly excavated by Cumont. We are going to bring this excavation to completion. The results of the excavation of this temple were thus far very striking indeed. The temple was not only a center of religious but also of a brisk social life. In a theatrelike building the men of the city came together not only to carry out religious ceremonies, but also to discuss municipal affairs. Another theatrelike building was reserved exclusively for women. Large courts and narrow chapels occupied the center of the temple. The main gate of it has not yet been found.

Fig. 5. Typical Parthian horseman.

Another not less important sanctuary arose in early times in the Southwest corner of the Parthian city. It existed here before the city walls had been built. It was dedicated in its early period to another Partho-Babylonian deity—Bel. The temple is famous because of its rich pictural decoration. The wall paintings of the temple had been ordered in the Ist century A. D. by a Macedonian, one of the richest and most influential citizens of Dura. And it is he who appears in his half Parthian dress with his Semitic wife and Graeco-Semitic children, all dressed according to the Parthian fashion on the walls of the sanctuary as builder and donor in the company of some Partho-Babylonian priests, the Persian "magi" who in their white pointed caps perform a libation to the great god Bel. From this temple the excavations of Dura started, since it was this temple which had been discovered by chance in 1920 and in it were the frescos which, copied and published by Breasted and Cumont, made the name of Dura famous in the scientific and artistic world.

However after two centuries of happy life under the Parthians Dura entered in the IInd century A. D. in its third and last stage of development. The peaceful policy of the Roman Empire did not last for very long. With Trajan at the beginning of the IInd century A. D. begins a period of renewed attempts of Rome to conquer Parthia. Trajan took the lead. He was followed by M. Aurelius and L. Verus, by Septimius Severus,

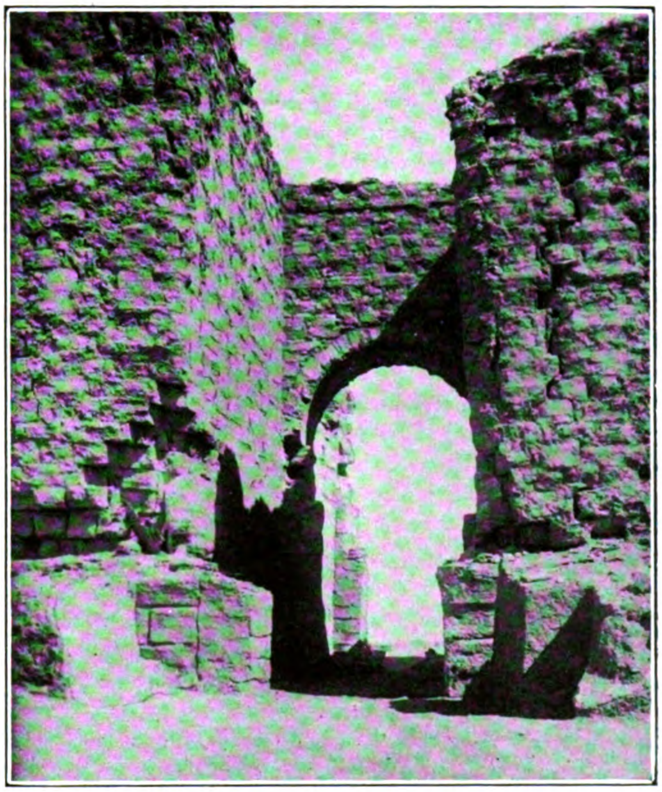


Fig. 6. (Negative) The main gate of Dura through which the caravans from Palmyra entered the city of Dura.

by Caracalla and Alexander Severus until under the last the Parthians were replaced in Asia by the Persians, the Arsacids by the Sassanians, and the Romans had to fight for their life with the vigorous new masters of the Iranian lands. In the campaign which was carried out against the Parthians by L. Verus, Dura was taken by the Romans and became a Roman fortress. As such it existed for another hundred years when it perished in the turmoil of the bloody chaotic IIId century A. D. never to come to life again. In the second half of the IIId century A. D. the prosperous and happy city became forever a piece of desert.

To our knowledge of Roman Dura which was very scanty after Cumont's excavations our excavations contributed a good deal. From 162 A. D. the Roman soldiers, soldiers of Roman legions and cohorts replaced the Parthian warriors. Latin speaking officers took up the duties of the Parthian governors and Roman veterans settled in the city along with its old popula-

tion which still spoke Greek in spite of a long period of Parthian domination and of the constant intermixture with Semitic and Iranian elements.

In the Roman Dura no doubt the Roman soldiers played the most conspicuous part. The first thing they did was to build a comfortable camp for themselves. They occupied the citadel and all the area between the citadel and the sanctuary of Bel. Here they built their "campus"—their "field of Mars" like the one in Rome, and in it a little sanctuary dedicated no doubt to the cult of the emperor. This sanctuary has been unearthed by us in our last campaign.

Another sanctuary the same soldiers probably took over from the Parthians. It was the sanctuary which occupied the central court of the main gate of Dura and perhaps one of its towers. This sanctuary was dedicated to the goddess protectrice of Dura —the Hvaeno of the Iranians, the Gad of the Semites, the Tyche of the Greeks, and the Fortune of the Romans. "Tyche Duras" was her name in Greek. Hundreds of inscriptions of the gate: short texts scratched, cut and painted on the walls and longer dedications cut into the surface of altars recommend the dedicants: officers, soldiers, custom officers, guards or gate keepers, both Greeks and Semites to the attention of the goddess. In the "sancta sanctorum" of this sanctuary stood a little wooden shrine with the image of the goddess, one of the doors of which with the figure of a Victory crowning the Fortune of Dura we discovered in our last campaign. Finally in the old sanctuary of Bel the soldiers of the Roman time and mostly of Palmyrene origin made some important changes. They rededicated the sanctuary to the Palmyrene triad of gods and they redecorated a part of the walls. One of these decorations is the famous picture of the sacrifice of the soldiers with their officer to the gods of Palmyra and to the two Fortunes—of Palmyra and of Dura.

However, it was not only religion which occupied the minds of the Roman soldiers. They wanted to have a pleasant time at Dura. The Romans had taught these Syrians to be clean and to like a bath. And the first thing they did was to build a comfortable bath in Dura with all the devices of the technique of this time: cold and hot water, central heating, warm floors and walls, large and beautifully adorned club rooms and what not. This bath was similarly unearthed during our last campaign.

Such is Dura as it presents itself now after five years of excavation. Those who are interested in knowing more about Dura may read the excellent book of F. Cumont Fouilles de Doura-Europos, Paris 1926 and our First Preliminary Report published recently by the Yale Press. Better still is it to go to our beautiful Museum and to look at the things which we have excavated and which are exhibited in four show-cases in the main hall of the Museum. Almost all objects of historical importance which have been discovered by us at Dura were kindly granted to Yale by the Syrian Government. They were carefully shipped to New Haven and placed in the show-cases by Professor Clark Hopkins, the Yale representative at Dura in the last campaign, to whom, with Mr. Pillet, the director of the excavations and Mr. Jothan Johnson, the second assistant, belongs the honor of the discoveries of the last year at Dura.

However it would be a mistake to say that the work at Dura has reached the stage when further discoveries would not add very much to our knowledge. On the contrary, we have just begun the real work. The most important problems still await their solutions. By starting systematic excavations at Dura Yale acquired great glory in the eyes of the scientific world but at the same time it took a heavy obligation, the obligation of carrying out the work and of bringing it to its happy end. And for doing it at least another five campaigns of steady and energetic work are required.

THE SIGNIFICANCE OF ELECTRIC LIGHTING

(Continued from page 16)

These are the means of producing modern illumination. They have come from the development of the sciences, principally of chemistry and physics, out of the scientific method of thought and of research. They are the fruition of the efforts of scientists and inventors and engineers and manufacturers. And what does the new light do for us?

Loss of sight is dreaded as the keenest of misfortunes. But without artificial light all of us lose our sight for half of the time, except as the moon may be unobscured. It is "the great increase in time effected by the unlimited supply of light" which Mr. Dunham realized was one of the great factors which have changed our modes of life. Normally the daylight hours are principally occupied in work for one's livelihood. Eight hours for work, eight hours for sleep and eight hours of opportunity—for recreation, for leisure, for development, for the better things of life.

But many of these hours come in the night time; light makes them useful. It is significant that books and periodicals have enormously increased as home lighting has increased. Writers and makers of books may owe much of their prosperity to better and cheaper light. Better light is coincident with larger attendance at high schools and colleges (a fourfold increase in the past sixteen years) and rapid growth of night schools, correspondence schools and adult education.

Good Industrial Lighting Offers Benefits Out of All Proportion to Cost.

Good industrial lighting lessens mistakes and promotes accuracy and quality, it increases output, it reduces accidents, it humanizes working conditions and its cost per day is comparable with the wages for only a few minutes. Our national increased output and lessened cost in productive industry is the basis of our recent prosperity. What would happen if we were suddenly forced back to the flaming oil lamps or torches and flickering gas of 50 years ago?

In railroad operations one may list the brilliant illumination of coaches (some of us can recall the smoky oil lamps which seemed to radiate mere gloom), the headlight, the signal lamps and the floodlighting of freight classification yards.

The automobile driver can go faster if he can see further; the headlight is the key to speed and safety. With the light of 50 years ago the automobile could not be what it is.

Commercial aviation calls for lighted airways and landing fields. In ancient times theater performances were of necessity by daylight. Artificial light makes the night better than the day; it is a powerful adjunct to scenery and performance. The movie film depends on powerful light for its production and for its showing and without the new lamps the movie of today could not exist.

Street lamps date back only a few hundred years, street lighting only a few decades. Compare the feeble lamp which marked the street corners with the brilliant modern street.

(Continued on page 46)

Metaphysics of Modern Physical Science

The Theories of Modern Physics have Uncovered Metaphysical Questions in the Philosophical Background which were Formerly Hidden by the Doctrine of Positivism.

By Dr. Henry Margenau

THE growth of physical thought up to the advent of the theory of relativity has been the gradual appreciation and fuller recognition of Newton's conception of nature: his great discovery of the essential reducibility of nature's varied performances to one fundamental mechanical law marked the scientific trend of succeeding centuries. The scientific method of that epoch was the investigation of motions, the subsequent demonstration of forces which caused these motions, and, finally, the discovery of other phenomena in which these forces also became manifest. There was no particular doubt about the meaning of physical laws; they were uncritical statements of supposedly inherent regularities in the processes of the world unquestionably exact in their mathematical formulation. Science was a body of descriptive facts whose preeminent status was seldom disturbed by the troublesome clinging of superfluous or conflicting theories. Happily there was usually but one theory which enjoyed complete experimental verification; it was promoted to the rank of a scientific truth while alternatives were swept away by the current of events. So cogent seemed the agreement between hypothesis and observation, so forcefully persuasive the simplicity of explanations—which, as we now believe, was due largely to lack of precision and fortunate limitation in experimental investigations—that scientific workers began to believe in the uniqueness and ultimacy of their code of laws. To be sure, the knowledge of nature was by no means supposed to be complete; new facts were to be discovered but they would merely weave new meshes into the already existing network of physical laws. The world was about to surrender to the conquering mind of man.

It is not strange in view of this situation that the doctrine of positivism pervaded the scientific philosophy of that age. Speculation, at least in its more detached form, was denied entry to the realm of science. The writings of Newton and almost all later scientists of this period are full of polemic against hypotheses. Why then speak of metaphysics involved in classical physics? Scientific men of the last century would, perhaps, strongly resent our query as to the metaphysical implications of their accepted theories, partly because the efficacy and beauty of these theories withheld from the investigating mind the thought of a philosophical understructure, partly because of the perplexing naivete with which most scientists, including above all Newton, accepted the metaphysical concepts shaped by their intellectual ancestry, entirely unaware of any transcendental content. In the following we shall deal only with those metaphysical elements in classical physics which have undergone distinct modifications in our modern developments, and it will be seen that even their number is not inconsiderable.

First of all there is the belief in the objective existence of an external world, supplemented by the conviction that our laws can describe it adequately. Molecules, atoms, ether, are real components of nature, not merely symbols of explanation. Their remoteness from our experience is conditioned by the imperfections of our senses only. Newton even suggests that, with sufficiently powerful microscopes, one might see some of them.

Another definite metaphysical postulate which was unconsciously adhered to in classical physics concerns the general validity of laws. A law, once recognized to govern a certain phenomenon of ordinary measurable dimensions, was supposed to regulate the same process on any other scale of magnitude as well. For instance, as the earth attracts the falling stone, so does it hold the moon in its orbit, and in like manner is the smallest particle of matter attracted by its neighbor. Indeed the simplicity of classical concepts arose chiefly from this supposition, which is completely abandoned in recent physics. The observer played a very subordinate role in the general scheme of classical things. He was merely a phase in the course of events; physical laws had been projected into an infinite external space in which they could be discovered alike by each skilful and unbiased observer. A good investigator equipped with ideally accurate devices would find a law to hold precisely in all instances, independently of the method by which he measured its effects, independently of his own circumstances or point of view. Divergencies in the functioning of a law were always attributed to faulty perception, a procedure which epitomized the positivistic view.

One dogma of classical physics never would have called for critical comment if recent developments had not discarded it: it is the assumption, generally embraced by scientists of the last generation, that nature be explicable in terms of our commoner experience. Newton endows the smallest particles of all bodies with "extension, hardness, impenetrability, mobility, and vis inertiae", properties which are all derived from our perceptual contact with ordinary bodies. The need for widening the range of concepts useful for physical explanation to include more formal and abstract notions was not felt in the period preceding the era of quantum mechanics.

It is quite in conformity with this general situation that mathematics was held within descriptive bounds. To be more specific, mathematical analysis was not in general allowed to start off on wholly unverified premises in its search for new knowledge; inasmuch as it was not applied deductively to formulate laws, it served to connect, by means of known laws, unrelated experiences, or to establish new ones on the basis of those that had been verified.

Modern advances in physical science, known as the theory of relativity, quantum mechanics, and wave mechanics have caused quite radical changes in these metaphysical particulars. So thorough has been the readjustment of the scientific attitude that metaphysics has suddenly emerged from its hiding place behind physical hypotheses, not shamefully penitent of its appearance but as a legitimate competitor for truth. Scientists are talking and writing about metaphysics, discussing the foundation of their logic, analyzing the function of causality and probability, working, in fact, on very definite epistemological questions. Physical theories have grown up wildly around a few significant experimental facts, facts so novel and delicate that older hypotheses seemed quite inadequate for their explanation. And what is more, the new theories found uniquely suitable to account for

these discoveries were not the natural and logical complements of the old ones, but conflicted with them in some most essential physical respects and were at variance with accepted metaphysical doctrines. It was the physicist who fitted the new knowledge into the general scheme of things; it is no wonder that his chief concern was pragmatic, that he selected modes of explanation which led most directly to observed facts, that the new metaphysics became a by-product of his professional labors. Hence the metaphysical elements of modern physics are unsystematically introduced and most curiously mixed, admittedly so, for the physicist is too busy with his own fascinating conquests to straighten out his philosophy. He is no longer at leisure to philosophize sedately about his discoveries; if his cosmology is to be complete he must count on the assistance of the philosopher who, most unfortunately has failed to learn his lingo. It is fairly certain that, in the process of final adjustment, the philosopher will have to perform some feats of surgery upon the body of the physicist's new metaphysics, which will probably be less serious in its infancy.

By new metaphysics we do not mean a well defined and clearly propounded set of doctrines. In view of the variety in scientific taste and the youthful haziness of physical theories it can only refer to the general metaphysical attitude of working physicists. To most of them nature is still an external structure of transcendental reality, largely independent of our mind. Our laws still describe it, but doubt is entertained in some quarters as to whether they describe it adequately and completely. The status of ultimate physical conceptions such as atoms, electrons, quanta is gradually changing; an increasing number of scientists have accustomed themselves to thinking of them as fictitious entities in Vaihinger's sense. They may not be actually present, they would say, but our experience is consistent and intelligible if we assume their existence, furthermore they have proved useful in promoting new discoveries. It appears that the relation between interpretative notions and external realities is no longer quite as direct as it was in classical physics: identity has given way to mere correspondence. However problematical this question may be, the solid old objectivism is decidedly shaken.

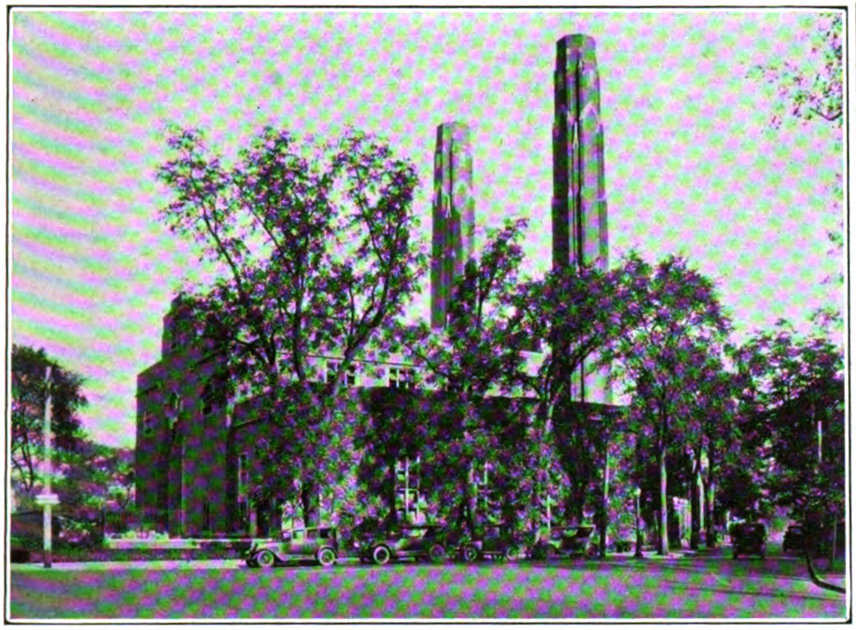
The mechanistic theory has been the most successful system of explanation before the development of the quantum theory. Its aim was to interpret all natural phenomena in terms of motions of discrete material particles, subject to the action of attracting or repelling central forces, whose magnitudes are functions of the distance between the particles. The success of this theory was so remarkable that it promised to unite all of physics, even all science to one grand, monistic cosmology of attractively simple features. Its principles applied equally to all sensible experience, and scientists gained the satisfying assurance of its uniqueness and finality. We now know that this system has broken down; we can state almost exactly the range outside of which its axioms fail to apply. This state of affairs would not be very disturbing if the mechanistic view had been supplanted by a greater physical doctrine equally successful on the whole and having a wider range of application. But that is not the case. The mechanistic theory still reigns supreme in its old domain while the quantum theory rules in other fields. Clearly then, unity of explanation is impaired. Physics has developed pluralistic traits which obviously require metaphysical adjustment.

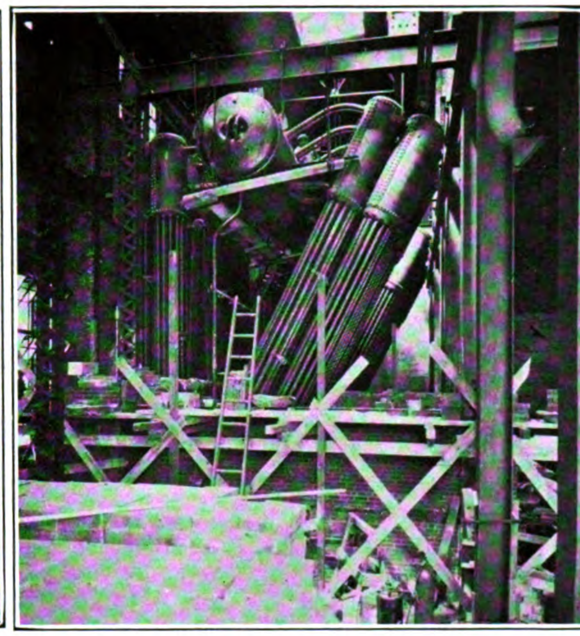
We have seen that the firm belief in the unconditional and objective functioning of natural laws has begun to crumble as the result of a new attitude regarding the reality of ultimate concepts. In one sense there has occurred even an intrusion of subjective elements into the scheme of physical laws. The theory of relativity has taken the observer from his detached and lonely stand, it has placed him in the midst of nature's workings and made him not only a vital part of the universe but a factor on whom perceptual phenomena quite essentially depend. One event may appear differently to observers in different circumstances—that was a recognition as subversive as any which have been made. Its consequence is of profounded metaphysical significance: there is no single, unique way in which the universe may be described properly to all observers. It is peculiar that a theory of such evasive and diversifying character sprang from an attempt of unifying the world mathematically. The special theory of relativity, to which we are here referring, comprises nothing but the logical implications of the thesis that all physical agencies, light and electricity as well as mechanical masses, behave alike in certain respects. It may be said that Einstein in extending uniformity over the realm of physical science created an infinite number of different worlds, each dependent on the viewing subject. If laws are understood to be the form in which the regularity of occurrences is described, then they, too, suffer the changes of an individual's point of view.

But relativity does not dissolve the universe into an unmanageable diffusion of arbitrary elements, for it states rules by means of which the different worlds may be connected. We are still able to perform a synthesis which leaves intact the antonomy of physical laws. The latter, however, is seriously attacked by the quantum theory, which asserts that laws found valid in ordinary experience need not apply to systems as small as the atom. One may examplify this well known situation by reference to one of the postulates of Bohr's theory which is in flagrant contradiction to the principles of electrodynamics, but we shall select for consideration a more fundamental issue: the status of causality. Previously regarded as one of the most basic categories causality had served to lead human inquiry out of the perceptual universe into the region of things in themselves; the same principle had been employed even to order the contents of that transcendental world: now it has not only been restricted to govern the phenomena of the physical world, but has in addition been denied application to atomic processes. To be exact, this does not reflect the credo of all physicists, nor could the absence of causation in elementary events be said to be proved. Yet it is nevertheless true that modern quantum theory formulates and solves its problems not in terms of causation but of statistics. It takes definite account of the possibility that the causal nexus may be interrupted in microcosmic events, and the thought that such an extreme innovation be a convenient mode of representation rather than the truth has been reduced to a mere hope.

Classical physics held the dogma that the only obstacle in the way to perfect knowledge of nature was the imperfection of measuring instruments. The difficulties were of a practical character, measurements were forever finite, discontinuous; theoretically there was no reason why atomic processes, for instance, should be unknowable; calculus had been invented just for the purpose of penetrating the last intricacies of a continuous nature. The uncertainty principle, one of the more recent consequences of quantum mechanics, denies that pronouncement. It asserts

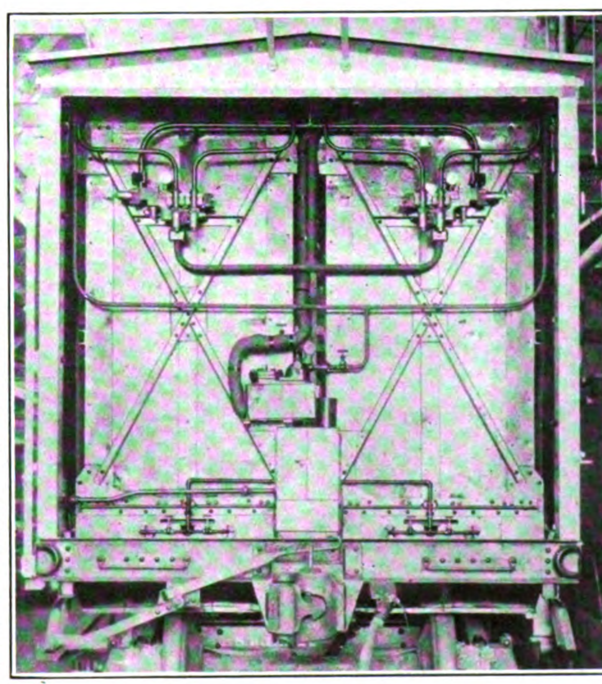
(Continued on page 38)





ABOVE RIGHT.—*One of the three Bigelow-Hornsby boilers of 500 H. P. each, now being installed in the Yale Power House to take care of the expanding needs of the university. They are fired by Riley stokers driven by individual Moore turbines. A Foster superheater is used. These three boilers bring the total number of this type and size up to eight. The steam is run through turbo generators which act as reducing valves, their exhaust steam being used for heating many of the university buildings.*

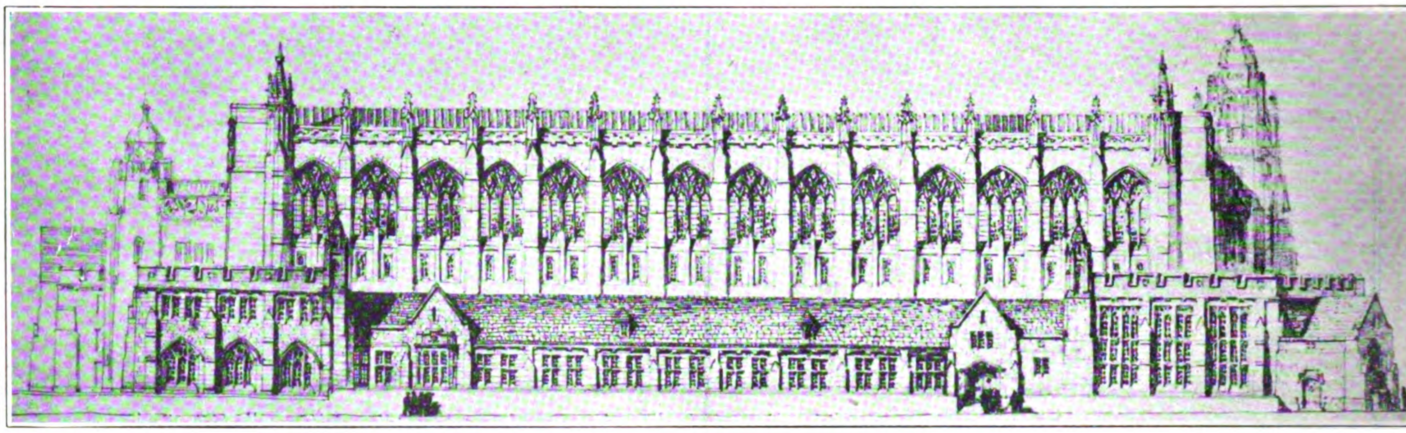
ABOVE.—*An outside view of the power house. The stack at the left has just been completed to serve the new boilers.*



RIGHT AND BELOW.—*A refrigerator car of a new type built by the Safety Car Heating and Lighting Company. The car is cooled by a self-contained refrigerating plant of the adsorbtion type. A Pintsch gas flame heats one of two units or groups of adsorber tubes containing silica gel, a special form of silicon dioxide, driving off the adsorbed refrigerant, sulfur dioxide. This is led from the adsorber to condensing tubes on the roof. When it is condensed it is led through a float valve to evaporating coils which cool the car. The sulfur dioxide is then adsorbed by the other of the adsorber units, which are heated and cooled alternately. It is thus possible to maintain temperatures as low as 18°F. for a period of eight days with practically no attention and with a temperature variation of 4°F.*

ABOVE.—*The equipment end of the car showing the two odsorber units. The case containing the control mechanism may be seen directly above the coupler.*

BELOW.—*Dr. Loomis Havemeyer who has recently been appointed Assistant Dean of the Sheffield Scientific School. He received his PhB. degree here in 1910, his A. M. in 1912 and a PhD. in 1915. Since 1920 Dr. Havemeyer has been Registrar of the Scientific School, in which he has been Assistant Professor of Anthropology since 1925.*



ABOVE.—*An architect's drawing of the new Law School buildings looking West from Grove Street. This building, the gift of the trustees of the Sterling estate, is to house the entire law school.*

The block bounded by High, Wall, York and Grove Streets is to be occupied by this quadrangle which is to be somewhat similar in ground plan to the Harkness Memorial.

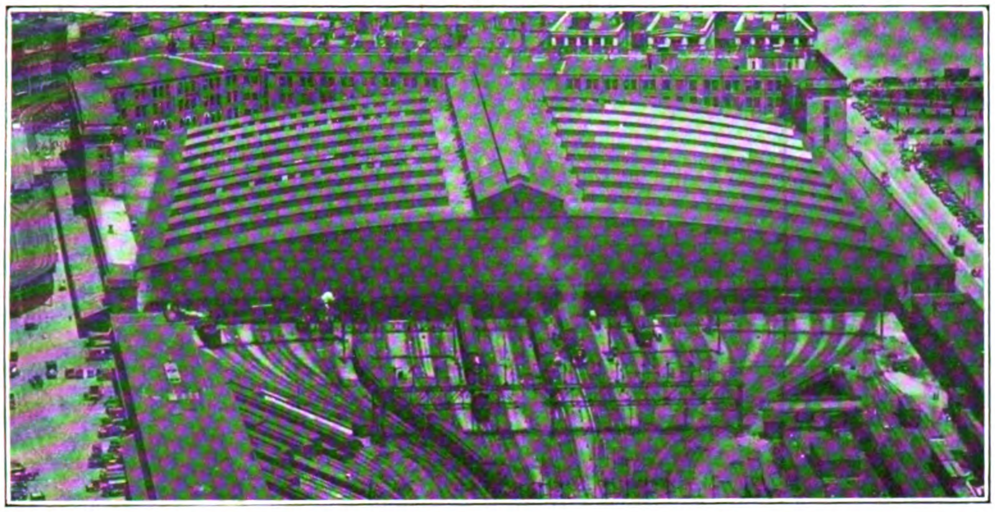
The dormitory sections are to face on York and Wall Streets while the dining rooms and the auditorium are to face Grove Street.

RIGHT.—*A view showing the present progress in the construction of the Law School buildings. This excavation is approximately under the facade of the building shown above.*

LEFT.—*Much progress has been made in the construction of the Sterling Library since we published photographs of the remarkable book tower framework in January. This picture was taken from the corner of High and Wall Streets.*

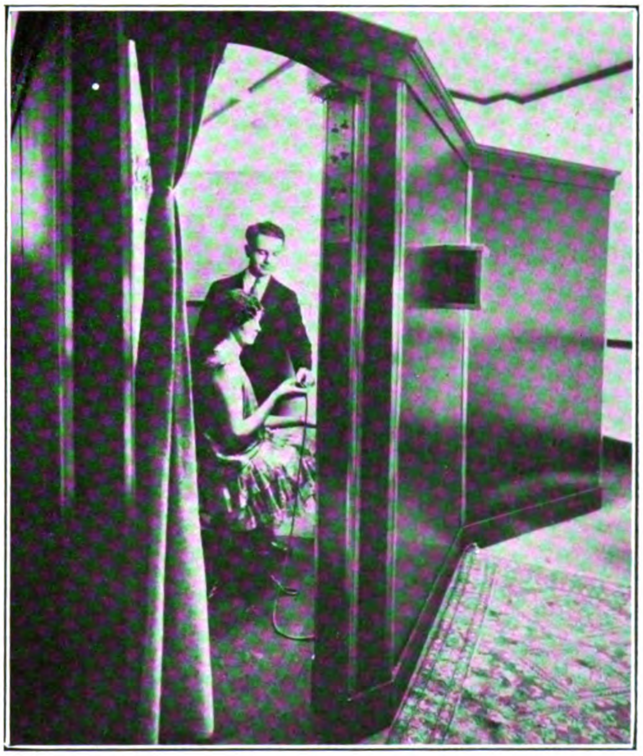
BELOW.—*Another and more recent view of the tower from the opposite corner of the block. The cleared space in the foreground will be used for the construction of the first of the new residential halls, as soon as the gymnasium has been removed.*

LEFT BELOW.—*The Cedar Street entrance of the new Institute of Human Relations Building which is now being built with funds made available by the General Education Board and the Rockefeller Foundation.*



ABOVE.—*The train shed of the South Station of the New Haven and Boston and Albany Railroads now to be torn down after a useful life of only thirty years. At the time of its construction this train shed was the largest railway building in the world with its length of 700 feet and width of 650 feet. There are about 9600 tons of structural steel in the three arches which support the roof. More trains per day are now handled from this station than from any other in the country.*

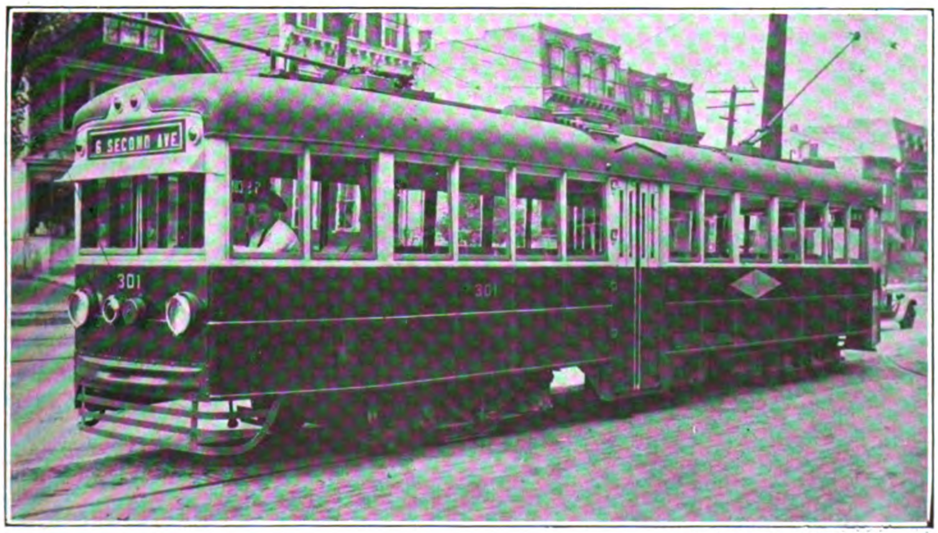
RIGHT ABOVE.—*The less spectacular but cleaner and more effective butterfly shed of the type shown here is to replace the old roof.*



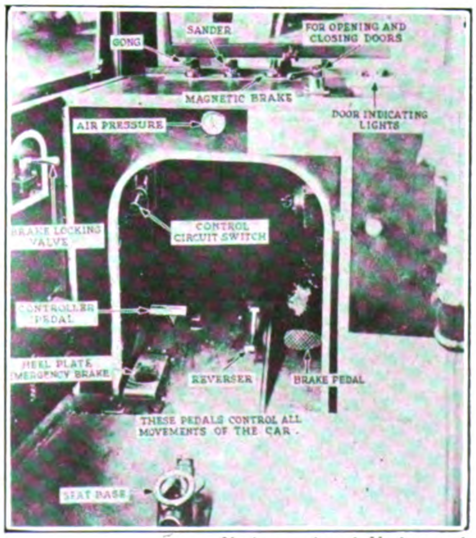
RIGHT.—*The "Photo Reflex" being demonstrated by its inventor, Luther J. Simjian, Director of the Photographic Division of the Yale School of Medicine. Through an arrangement of reflecting lenses and an invisible camera it is possible for the sitter to see in reduced scale the image exactly as it will appear in the finished photograph. The photograph is taken by the subject as soon as he is ready, self-consciousness being thus eliminated. The results obtained from this device have compared very favorably with photographs taken with the best of modern studio equipment.*

BELOW.—*One of the new trolley cars that are now being developed. This car is being tried in actual service in Albany, N. Y. The lighter weight made possible by careful design and the use of lighter alloys, allows quicker acceleration and braking and helps to reduce noise. Roller bearings and improved trucks improve acceleration and riding qualities. Four methods of braking are available, regenerative, magnetic, air and hand. Foot operated controls for the car make possible faster loading as the motorman's hands are free for handling fares. This car has been found to be capable of reducing the time over the route by 20%.*

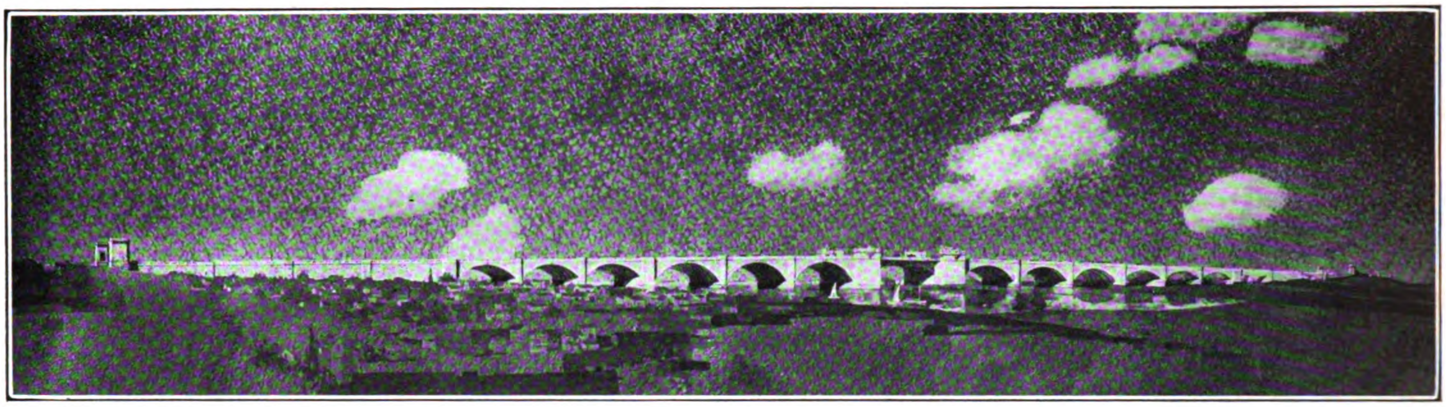
BELOW AT RIGHT.—*A view of the motorman's automotive type controls showing the convenience of their location.*



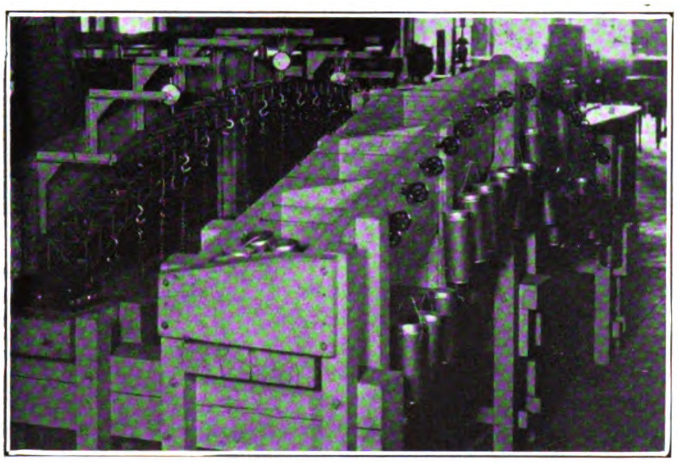
Underwood and Underwood.



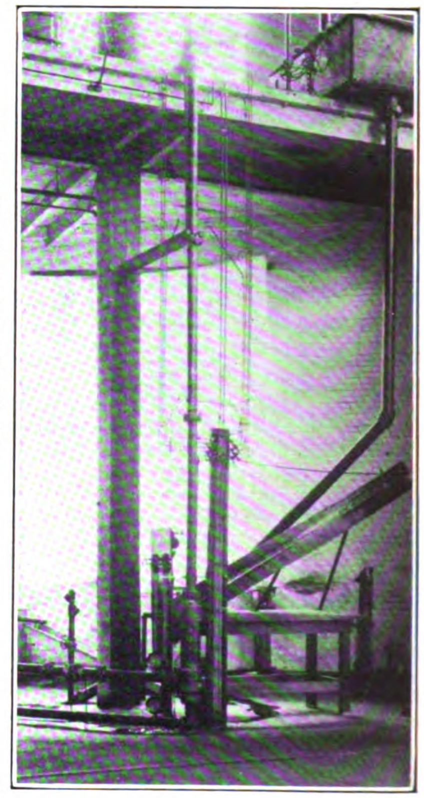
Underwood and Underwood.



ABOVE.—*The Washington Bridge across the Seekonk River at Providence, Rhode Island now nearing completion. The total length of this graceful bridge is 2407 feet. The double leaf Bascule drawspan gives a horizontal channel clearance of 100 feet and a vertical clearance of 43 feet above mean tide level.*



ABOVE.—*A working model of the Kill Van Kull bridge. This 9 foot model was built to check the computations of the designing engineers. It was very carefully built to scale, and was equipped with instruments for accurately measuring the deflections under wind and load strains. The results obtained with the model agreed with the calculated values very closely in all cases. An interesting effect is noted when a load is applied near one end of the bridge. The other end will be raised almost as much as the loaded end is lowered. The model is now on display at the Museums of the Peaceful Arts in New York where visitors are allowed to study the effects of loads on the model. The bridge itself is to be the longest arch bridge in the world, its center span being 1675 feet and weighing 34,500,000 lbs.*



RIGHT. *This apparatus in the Mason Laboratory of Mechanical Engineering is being used in an attempt to simulate the natural circulation in the vertical water tubes placed at the walls of large boiler furnaces. Varying quantities of air, under control are introduced at the tube periphery through many small orfices, into a column of water which is forced through the tube. This is done in order to determine the influence of the air on the resistance which is offered to the flow of the mixture through this tube. The air takes the place of the steam bubbles which form at the tube surfaces in actual installations.*

BELOW.—*The Outerbridge Crossing between Perth Amboy, New Jersey and Tottenville, Staten Island, New York. The picture of this highway bridge was taken from the New Jersey Shore. The total length of the bridge and its approaches is 10,200 feet. The central span of 750 feet has a clear height of 135 feet.*

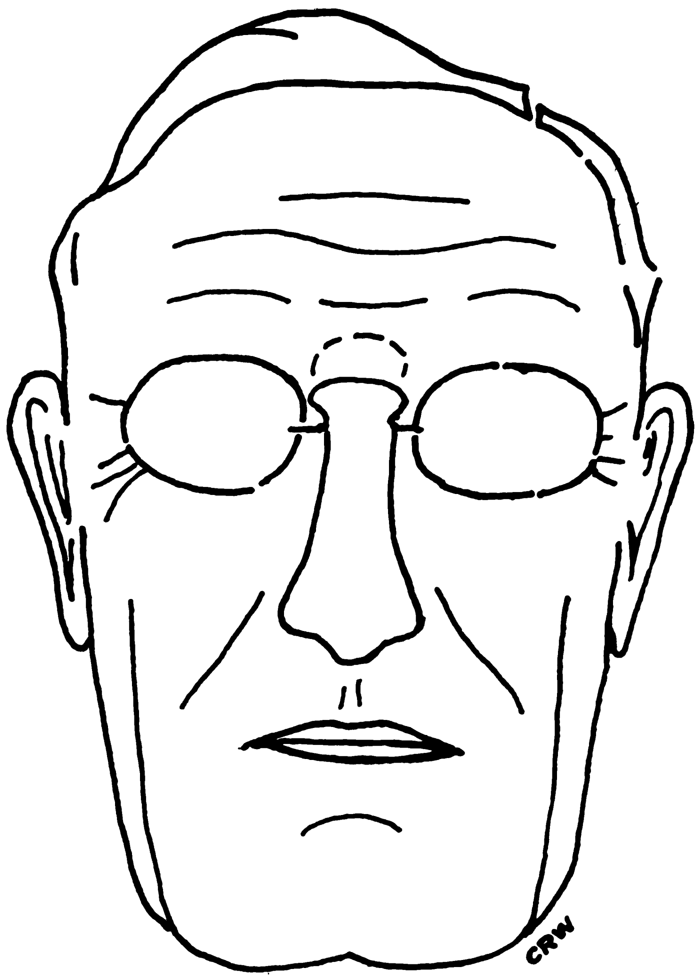
P·E·R·S·O·N·A·L·I·T·I·E·S

JOHN CLAYTON TRACY.

IN September of 1887 a seventeen-year old fair-haired boy from Fair Haven, with a far-away look of quiet determination in his eye, mingled with a shy reserve, walked into North Sheffield Hall and enrolled for the Ph.B. degree, with some 106 others, giving his name as John Clayton Tracy and stating that he was born at Willimantic, Connecticut and had prepared at the New Haven High School. He was not the only serious-minded boy in a class which included Oliver Smith Lyford (now a leader in the Yale Engineering Association), Charles Louis Kirschner (later to become principal of the New Haven High School) and Alexander William Evans (now our Professor of Botany)—but he took his seriousness seriously. He himself confesses, for example, that, come what might, he invariably rose at 6:15 A. M. (e.s.t.) and retired at 9:00 P. M. His classmates soon found that John had in him the makings of a scholar and they enviously dubbed him "Old Accuracy". At graduation, in 1890, they even put him into rhyme,

"What troubles me most is
the Flubdubism
Of other people's Inaccuratism".

Shortly thereafter Tracy, in a bridge company in Cleveland, was deeply engrossed in intricate problems of design that brought into play his innate fondness for precision and methodical methods of procedure, such as the design of the steel roof framework for some of the Chicago World's Fair buildings. Later he joined our Civil Engineering faculty, which up to that time had consisted of one professor and one instructor. "Bridge Design" was the subject of his thesis when he was awarded the C. E. degree in 1892. Besides teaching bridge design and other civil engineering subjects he took from Instructor Lockwood's shoulders the course in Mechanical Drawing, then taught to all Freshmen in Sheff. Realizing the need for a textbook in the latter subject, he began at once on its preparation, and in 1898 there appeared his first book, *"An Introductory Course in Mechanical Drawing"*, an original and even revolutionary text which was widely adopted. Although Instructor Tracy preferred teaching to designing bridges, he drifted back occasionally to the King Bridge Company and put in a summer's recreation on some difficult problems purposely saved up for him there. He was promoted to Assistant Professor of Structural Engineering in 1902.



His most popular work, *"Plane Surveying"*, a textbook and pocket manual of some eight hundred pages, was published in 1907. Nearly one hundred thousand copies have been issued, and it still finds wide acceptability by virtue of its comprehensive thoroughness and the practical nature of its contents. In 1914 appeared a third text, *"Descriptive Geometry"*, written in collaboration with Herbert Brinkerhoff North. The latest text in the Tracy series, and one on which he has spent much of his spare time for ten years, is *"Stresses, Statically Determined"*, published last spring. If there is any phase of this abstruse and puzzling subject not lucidly and exhaustively treated between the covers of this book of five hundred double pages, the (author) does not know which it is.

On the sudden death of Professor DuBois in the fall of 1915, Professor Tracy was advanced to full professorship and appointed to succeed him in charge of the Civil Engineering Department, thus becoming third in the distinguished line which began with Professor William Augustus Norton in 1852.

A teacher of engineering and of ethics, an idealist to whom martyrdom for his convictions would always be preferable to abject capitulation to expediency, an organizer second to none this side of Washington, D. C., and a man who, with his eye on a chosen objective, is not easily diverted or discouraged by difficulties and distractions, such is John Clayton Tracy. Director-Emeritus. Chittenden, in his recent *"History of the Sheffield Scientific School of Yale University"*, says of Professor Tracy "The thoroughness of his work in all directions of University activity, combined with his high ideals of engineering education, have made him a most valuable member of the engineering section of the School. Devoted to the advancement of civil engineering in all its branches, he has been always zealous to aid in every movement that promised improvement over existing methods, or that held out the hope of increased usefulness in the field of civil engineering."

Professor Tracy is, like some of the rest of us only more so, two persons rolled into one. For six days in the week and nine months of the year he daily ponders the injunction contained in Genesis, *III, 19;* his favorite line of poetry is "Life is real, life is earnest", and if he ever takes time to whistle it is never

(Continued on page 40)

Medicine

The Psychiatry Conference, on March 21, was addressed by Dr. William A. Malamud of the Foxboro State Hospital on "The Sense of Reality and Disturbances of It that are met with Mental Disease."

On May 23, 1929, Dr. Harry C. Solomon, of Boston, addressed the Psychiatry Conference on "The Effect of CO_2 on Certain Cases of Stupor."

Under the auspices of the Plant Science Club an illustrated lecture was given on April 19 by Professor F. E. Lloyd, of McGill University. The subject was "The Feeding Habits of the Microscopic Animal Vampyrella and the Water Plant Utricularia."

The May meeting of the Society for Experimental Biology and Medicine was held in New Haven on May 25.

Civil Engineering

On May 11 the Yale Engineering Camp was the scene of a gathering of forty-six engineering teachers from eight schools of engineering. The occasion was the spring meeting of the New England Section of the Society for the Promotion of Engineering Education. Dean Warren presided, and the speakers and subjects were as follows: Professor J. W. Barker, (M. I. T.) "Sectioning of Classes on the Basis of Mental Speed and Honors Work in Electrical Engineering at Massachusetts Institute of Technology", Professor E. D. Smith, (Yale) "The Teaching of Personnel Management", Professor E. J. Miles, (Yale) "A New Method of Teaching Calculus."

The Connecticut Section, A. S. C. E., entertained the Senior class, all of whom are members of the Student Branch of the Society, at a dinner on May 15th. Professor Bishop is vice-president of the section.

The Connecticut Society of Civil Engineers held its annual summer meeting at the Yale Engineering Camp on July 23. The weather was perfect and the day was a full one, devoted to looking over the camp, to general sociability, and to sports, with a chicken dinner served midway. Professor Farnham, chairman of the committee on arrangements, spoke during the afternoon on "The Yale Engineering Camp, Its Objective and Scope." Among the officers of this Society are the following Sheff. men; A. L. Donnelly ('08S),

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Mechanical Engineering

Professors Dudley and Wohlenberg served as lecturers in the Machine Design Division and the Heat Power Division of the Summer School for teachers of Mechanical Engineering held under the auspices of the Society for the Promotion of Engineering Education at Purdue University in July. Mr. R. L. Anthony of the Yale Mechanical Engineering staff was one of the 89 teachers of Mechanical Engineering enrolled in the School. For three weeks there were lectures and discussions, some for the whole group and others for the three sections, Heat Power, Machine Design and Production. There was a three day trip to the Western Electric Company's Hawthorne works where production methods were observed in action. The American Society of Mechanical Engineers was one of the sponsors of the session. One of its editors, G. A. Stetson, 1910 S., formerly on the mechanical Engineering staff at Yale attended the meeting and comments in a two page editorial which includes the following sentences.

> "There was, first of all, a reassuring conviction that teachers of engineering are on the right track. In an age of sudden changes and in a new environment, both attributable in a large degree to the impress of the engineer upon civilization, methods and purposes of education have undergone change also. While some have failed to recognize this fact, while others have been stampeded into ill-advised programs of speciality training, engineering teachers have been able to maintain a conservative balance with a progressive vision. What is more significant, they have and in this they are unique, boldly questioned their aims, ideals and methods, with a hope, which has been realized in part at least, of improving themselves, their schools, and their product. No other group of teachers has formulated so definitely its ideas in these essential points. ******* It was a golden opportunity for the young instructor to absorb in countless ways a realization of the significance and importance of his profession and to benefit by numerous very definite additions to his knowledge of the subject matter he is teaching. He met and talked with men whom he had read about, whose books he had studied, whose names had been heroic to him. ****** The schools to which these men return will benefit

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Mining and Metallurgy

The Department of Mining and Metallurgy has recently purchased a 20,000 lb. Hydraulic Testing Machine from the Southwark Foundry & Machine Company.

Professor Mathewson attended the combined meeting of the Institute of Metals (British) and the Gesellschaft für Metallkunde, held at Düsseldorf, in September.

Geology

Professor C. R. Longwell spent the summer in a trip to South Africa, to attend a meeting of the International Geological Congress. He stopped en route to examine the geology of the Northwest Highlands of Scotland.

The course in General Geology started the year with two new text books; the first volume of the Pirsson and Schuchert text has been thoroughly revised by members of the Yale Department, and a new book of collateral readings has been prepared to accompany this text.

Alan Bateman, professor of Economic Geology, left early last spring for the East Coast of Africa, journeyed across equatorial Tanganyika to the Belgian Congo, then southward through the Congo to Katanga and Northern Rhodesia, studying the geology briefly en route. He spent some time in Rhodesia and the Congo studying the geology of the region and in investigating the remarkable copper deposits of those regions. He then visited Victoria Falls in Southern Rhodesia and proceeded to South Africa to join the International Geology Congress as one of the delegates from Yale University. In connection with the Congress he visited the diamond mines of Kimberley and vicinity; the Johannesburg gold mines; deposits of platinum, iron, chrome, copper and asbestos in the Transvaal; and made an extended geological excursion through the Bushveld Igneous Complex. He returned via the West Coast of Africa and England.

A. K. Miller has been appointed instructor in the Department of Geology.

Five recent students of the department of Geology are now engaged in geological work in Northern Rhodesia, Africa.

Professor R. F. Flint spent the summer in Ireland, England, and northern Germany studying in the field the deposits left by the last glacial ice sheet.

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Botany

Dr. John S. Boyce, formerly Director of the Northeastern Forest Experiment Station, has been appointed to a professorship of Forest Pathology.

Professor George E. Nichols was a member of the faculty of the University of Michigan Biological Station during the summer session.

Professor Carl G. Denber and Dr. R. P. Marshall spent the summer on the staff of the Research Laboratories of the Bartlett Tree Expert Company in Stamford, Conn.

Chemistry

Bayes Norton, Yale 1926 S. has been appointed Instructor of Chemistry, after completing studies in Oxford as a Rhodes scholar. When an undergraduate, he was captain of the Yale Track Team.

John Vance has been appointed Instructor of Chemistry. He received his Ph.D. from Yale this year.

Alfred Brown has been appointed Instructor of Physical Chemistry after receiving a degree of Ph.D. here this spring.

Professor H. A. Curtis has been appointed Chairman of the newly formed Chemical Engineering Department. T. C. Lloyd and R. L. Copson have been appointd Instructors in the Chemical Engineering Department. Mr. Lloyd received his degree from Columbia University while Mr. Copson's was given to him by Worcester Polytechnic Institute.

Two new research fellowships have been announced, the Chemical Foundation Fellowship held by Dr. William Schmidt-Nichols, and the Alkaloid Fellowship held by Dr. R. H. F. Manske.

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Biology

The opening of the school year finds the Osborn Laboratory completely filled with students and foreign research fellows. The enlarged facilities of the laboratory made available by the complete refurnishing of the fourth floor has rendered available a number of rooms for private investigators, but even with this additional space the room capacity of the laboratory is completely occupied.

Among the foreign guests are: Dr. Ernst Scharrer, of the University of Munich, who is a Sterling Fellow; Dr. Hans Bytinski-Salz, a Sterling Fellow from the Kaiser Wilhelm Institute, in Berlin; and Dr. Walter Hellmich, from the University of Munich, who is also a Sterling Fellow.

During the summer the laboratory was used for research, Professors Baitsell and Nicholas being in occupancy for the majority of the summer months. Active research was continued by Professor Nicholas in collaboration with Mr. Hooker, upon the Central Nervous System.

The International Congress of Physiologists, who were entertained during their meetings at Harvard University, visited New Haven on Sunday, August 25th. Over 200 members of the Congress visited the laboratory and observed the demonstrations of the scientific work in progress.

During the meetings of the Psychological Congress, which were held here in New Haven, many of the distinguished foreign visitors were guests of the laboratory.

The majority of members of the staff and student body of the laboratory spent the summer at Woods Hole where they were engaged in study and research. During the summer vacation many problems were investigated, particularly those associated with the field of Invertebrate Zoology and Protozoology.

Physics

Assistant Professor William W. Watson, formerly of the University of Chicago, has joined the staff of the Sloan Physics Laboratory, having spent the last year doing research in spectroscopy in Germany.

Assistant Professor D. Albert Criter has returned to his duties after a leave of absence of two years.

Dr. Joseph E. Henderson, formerly Instructor of Physics has accepted an Assistant Professorship at the University of Washington.

Dr. George W. Gardiner, formerly instructor in Physics, has joined the research staff of the Bureau of Standards at Washington, D. C.

Dr. Malcolm Henderson and Dr. Dimitri Olshevsky are continuing their research work as Sterling fellows.

The National Research Council has published a revised bulletin on radioactivity by Professor A. F. Kovarik and Professor L. W. McKeehan.

Professor John Zeleny has recently had a paper published on "The Behavior at Impact of Jets of Highly compressed Air." He has also had published "The Distribution of Mobilities of Ions in Moist Air."

Forestry

Dean Graves devoted the early part of the past summer to completing the organization of the Forest Education Inquiry, with which he is serving as Director, and then visited various places in Colorado, California, Oregon, Washington, and Montana. Mr. Graves' trip through the West was concerned chiefly with his studies of the problems of applied forestry under the Charles Lathrop Pack Foundation.

Professor Toumey attended the meetings of the International Congress of Forest Experiment Stations at Stockholm, Sweden during July.

Professor Bryant spent four weeks during August and September teaching at the Cornell forestry camp at Newcomb, N. Y.

Professor Record has been appointed collaborator for Revista Florestal, a Brazilian forestry publication recently started in Rio de Janeiro, having for its purpose the conservation of forests and the assistance of industries concerned with timber and minor forest products in Brazil.

The summer session of the Forest School was held at the Yale engineering camp at East Lyme, Conn., from July 8 to September 10. Fifteen men registered for the course, which was conducted by Professor Chapman.

Electrical Engineering

In June Professor Warner attended a two week's Colloquium on Power Systems with particular reference to the stability problem. This Colloquium was held at Massachusetts Institute of Technology and was attended by about seventy engineers representing the manufacturers, operators, consulting engineers, and educators from various parts of the United States and Canada.

Professor Warner continues as Secretary of the Connecticut Section, American Institute of Electrical Engineers.

Professor C. F. Scott attended the Convention of the Society for the Promotion of Engineering Education at Columbus in June and presented a report as Chairman of the Board of Investigation and Coordination. The investigations conducted by Dr. Wickenden covering the general field of engineering education will form the basis of a two volume report which is soon to be issued.

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Yale Engineering Association News

DEPARTMENT OF

YALE ENGINEERING ASSOCIATION

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G. S. Moore, '27 S., *Assistant Editor.*

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ENGINEERING NEWS.

CALVERT TOWNLEY, President of the Yale Engineering Association, was born and grew up in Cincinnati, Ohio. He prepared for College at Chickering Institute in that city and was graduated from the Sheffield Scientific School in 1886, having taken the Mechanical Engineering Course. He continued his studies there in mechanical engineering, also specializing in electricity and was given the degree of M. E. in 1888.

After a short engagement with the Brush Electric Light Company in Cincinnati, he entered the employ of the Westinghouse Electric & Manufacturing Company at Pittsburgh and continued with them until the close of 1904. Being first engaged as Road Engineer he was thereafter transferred to the Sales Department, serving successively as Salesman, Headquarters Assistant to the Vice-President, Boston Manager, Assistant to the First Vice-President and General Agent.

In 1904 he became connected with the N. Y. N. H. & H. R. R. Co. as Acting Fourth Vice-President in charge of the electrification of their main line out of New York. Under his direction there were prepared studies and specifications for that undertaking which was the first steam railroad to adopt the single phase alternating current system and which established numerous practices which have since become standard throughout the country. Shortly after joining the New Haven staff, there were added to his other duties that of First Vice-President of the Consolidated Railway Company, a New Haven subsidiary formed to acquire and operate the numerous trolley lines and other utilities controlled by that road.

In 1911 he was re-engaged by the Westinghouse Electric & Mfg. Co. as a staff officer and has continued in that position to the present time with the title of Assistant to the President. During this latter period he has been occupied in many unrelated activities on behalf of his company. He served as President of the Lackawanna & Wyoming Valley Railroad, Vice-President of the Niagara, Lockport & Ontario Power Co., Vice-President of the International Radio Telegraph Company, which signalized Westinghouse's entrance into the radio field. At one time he had charge of his company's foreign investments and another spent six months touring South America. During the war he supervised the construction of a factory group and workmen's housing development near Philadelphia. In 1908 as a side issue he participated in organizing the Kolynos Company domiciled in New Haven and which manufactured tooth paste and other toilet preparations. He served as President of this company for nearly 20 years and until the company was sold to a holding company.

In 1901 Townley joined the American Institute of Electric Engineers and was active in its affairs for a long period, being elected President in 1919. He was Chairman of the organizing conference which put together American Engineering Council

and served that body as a Vice-President for a long period. He was married in 1889 to Edith W. Case, a sister of one of his classmates, who died in 1904. He has two sons, Clifford C., *ex* 1913 S. and Donald C., 1920 S.

SHEFF. POPULATION.

THE new college year has started and the number of men entering Sheff. continues to be unsatisfactory. Two hundred and nine members of the Class of 1932 have elected the Scientific School, a number which to our knowledge, is the smallest in the past decade. Following is a comparison between Ac and Sheff:

Class of	*Sheff.*	*Ac*
1929	260	554
1930	213	559
1931	230	557
1932	209	610

However, in spite of this situation which is to be attributed to many causes, it is our belief that a new element will shortly turn the tide. The new course in Applied Economic Science with a basis of the physical sciences, which is being offered in the School for the first time this fall, should have a broad appeal among the type of men entering Yale today. The course is in many ways comparable to the old 'Select' course which was so popular in Sheff. a number of years ago but it is undoubtedly more difficult. It should appeal directly to the men who now elect the Ph.B. course in the college.

Dean Warren pointed out, in the last issue of this magazine, that approximately one half of all the graduates of the undergraduate schools follow business or commercial courses after leaving college. Those employing college graduates in banking and investment or other business enterprises, have been increasingly insistent, Dean Warren points out, on a thorough knowledge of economic principles and of methods of scientific analysis as applied to the problem of finance and business generally.

Following is an outline of the course:

Common Freshman Year.
Similar to that of Yale College.

Sophomore Year.
Physics.
Elementary Economics.
Elementary Statistics.
Social Evolution.
Modern Language.

Junior Year.
Principles of Accounting.
Distributing Systems.
Industrial Physiology.
Business Law.
English or Elective.
Elective.

Senior Year.
Twelve credit hours from one of the following groups:

A. Accounting and Finance.
B. Transportation, Commerce and Public Utilities.
C. Statistics and Business Forecast; Industrial Organization; Personal Problems.

Course in Science, Engineering or Economics.
Electives to complete thirty hours.

The demand for a course similar to the above was evidenced by the fact that the population between Sheff. and Ac was balanced as long as the comparable Ph.B. course remained in the Scientific School but upset as soon as it was transferred to the College.

It is our feeling that this more attractive course should result in a rapid growth in the population of Sheff. It is the biggest news in years. The members of the Yale Engineering Association should make it their point to see that definite information regarding the course is given to all men contemplating entering Yale.

RUSH WEEK.

SEVERAL members of the Association visited New Haven recently and reported that the feeling between the Sheff. fraternities is very fine. This is due, to a large extent, to the efficient way in which the houses have taken up the difficult problem of Rush Week and worked out a satisfactory system. No doubt the members of the Association will be interested in hearing about the present plan.

Beginning the Friday before the Harvard game, no members of the Sheff. fraternities may associate with sophomore eligible for the houses. Calling begins the Monday after Thanksgiving, approximately one week later, and for two nights, the entire membership of the class is required to call for a definite period on each of the eight houses. The sophomores are divided into eight groups which call at all the eight houses in rotation.

On Wednesday, Thursday and Friday nights, the houses invite those sophomores they wish. The sophomores can accept or decline as they please. Pledges are offered on Saturday night. At the present time a new system is being considered which will extend the compulsory calling forward into the preceding week. By this scheme, it is felt that fewer men will call at one time, the houses will be less congested, and the men will have an opportunity to become better acquainted.

THE LIFE OF THE PROTOZOA IN TERMITES

(Continued from page 6)

It is a very interesting fact that the various species of termites have, in general, different kinds of flagellates. It would be a long story to attempt to give in any detail the description of all the kinds. It is believed that they originated from some common ancestor or ancestors and have since become so different. To find a new kind is not difficult if a new termite from some remote region is studied. The young termite seems to get its necessary quota of flagellates when it gets a few drops of digested material from the adult termite.

Some of the flagellates are cone shaped and have long flagella resembling a coat of hair covering the anterior or other parts of the body. Very frequently a dense covering of bacteria may be mistaken for flagella or cilia. The cilia are short hair-like processes which do not occur on the protozoa from termites but on those from other animals as the horse or cow. Not a few have the bodies wound around by a number of cords which usually appear dark when stained. The pointed end is usually inserted into the wall of the intestine and acts as a anchor. A long beak called a rostellum occurs in *Proboscidiella* and on *Oxymonas* a form on which the writer has recently been working. When a cross section of this was made with the microtome, a finely adjusted slicing instrument, and the sections examined, the beaks were all found fastened to the wall of the intestine. Of course all of these interesting animals are so small that not much can be learned about them unless they are stained and magnified from two to three thousand times. Some times they are examined with a dark field apparatus attached to the microscope and then they appear as white objects gracefully moving about with the flagella waving and acting as oars or propellers. The rostellum or proboscis, as it has been called, may be retracted.

In a few types, as *Proboscidiella* and others, the individual organism is really a multiple one, since it contains a duplication of the nucleus and other internal structures which occur in the single individual. There is a complex system of fibrils usually present. In *Trichmonas* there is a wavy membrane along the border and this aids in locomotion by undulating.

Although the study of these animals has been going on for about thirty years, it is only recently that the biological relation between them and their host the termite has been studied. There is still a large field for the discovery of new kinds since large parts of the earth remain where little or no study has been of the intestinal fauna of termites. The termites will live very well in the laboratory, as do their protozoa, on a diet of filter paper. The government, however, naturally prohibits the bringing in of these insects from other countries because of their destructive habits. It it therefore necessary to go where the termites live and make the desired microscopical preparation or have them sent prepared. It is always necessary to have the identity of the termite certified by some one.

THE LUBRICATION OF MODERN MACHINERY

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naturally would be produced from the various grades of crude oil by the old methods of refining and according to the old standards for gasoline quality.

Motor fuel was fast taking an important position and forcing kerosene into second place in gallonage and in revenue. To meet the demand, the refiners were forced to make the gasoline cuts wider in scope and to include more of the product that formerly was put into the kerosene tanks. Such motor fuel was more difficult to carburet because it contained too much of the heavy ends of the crude oils and these would not atomize and mix with air properly. Parts of the fuel formed droplets in the inlet manifolds and cylinders and did not burn completely; afterward, they drained down past the piston-rings and combined with the lubricant. This produced a thin characterless mixture of fuel and lubricant that was further contaminated with road dust that entered the engine through the carburetor, with carbon from the heavy ends of the fuel, and with the carbon and sticky residue of the partly burned lubricating oil that was creeping up into the combustion-chamber in increasing amounts as the oil became thinner because of being mixed with the fuel. The engines were also operating at a higher temperature on account of the heavier fuel and because of the means adopted for pre-heating the fuel. Later, the engines were also being designed so that they would develop more power and operate at higher speeds. This has caused the breaking-up or cracking of certain weaker parts of the lubricating oil, resulting in the liberation of a small quantity of gas, and of lighter petroleum products which escape through the breather or combine with the oil and increase its contamination still further.

Carbon formation always results from the cracking of oil under any form of destructive distillation such as that which can take place on the top or the bottom of a piston or in the combustion-chamber of an internal-combustion engine. Some of this carbon that does not stick to the engine parts enters the circulating oil, colors it black and adds to the general contamination. Such a conglomerate mixture cannot be considered an efficient lubricant under any of the rules of suitable lubrication. Its use could result only in considerable wear of the parts. Research men have found considerable traces of all of the metals used in making the bearings in samples of lubricant removed from automotive engines after every period of use. A real problem was developing.

The Contamination of Engine Lubricants

For many years the problem created by the contamination of engine lubricants has had the attention of the engineers of the combined petroleum and automotive industries. Each year solutions are offered, tried and discarded. Each year more millions of engines are being built on principles that allow a mixture of fuel and lubricant to be formed in the lubricating system. The road dirt that enters the engine with the air through the carburetor has been excluded to some extent by the development and adoption of air-cleaners. But some dirt still passes through these air-cleaners and accumulates in the oil-circulating system and carbon which enters the circulating oil continues to be formed in the engine; consequently, oil-filters were developed for the purpose of clarifying the oil as it circulates in the engine lubricating system.

Nearly all automotive engines are now fitted with three forms of apparatus that should filter out dirt and such water as might accidently enter the engine from the tank; the dust and dirt that goes into the engine along with the air that is taken through the carburetor; and the dirt, carbon and metal that accumulates in the oil itself. If these various devices adopted by the automotive industry function properly, a matter which is largely dependent upon the care given them by the operator and the regular renewal of their parts, then the lubricating oil should be clean of all solid contamination and to that extent should perform its work much better than if it were charged with material most of which can be classed as abrasive. But the problem has been only partly solved and the evil effects partly corrected. There still remain the bad effects of dilution of the oil by the fuel, and this situation is worse to some extent than it was when the problem first presented itself.

Suiting the Lubricant to the Machine

For lubricating every conceivable form of machine a lubricant specification can be written that will fully designate the kind of oil best suited to balance that machine completely with all of its economic requirements. Machinery can be grouped and classified, the various conditions can be averaged, and one oil specification can be derived that will suit all the conditions under which the machines must operate. When the most suitable lubricant has been determined, secured and applied through a modern circulating system, the entire balance of the economic factors is upset if any change is made from the specified lubricant, especially if the features that particularly have to do with its efficient performance as a lubricant are in any way allowed to undergo a change.

A cotton spindle, for instance, is designed for a very thin properly made oil. When such an oil is placed in the bath base the spindle will turn its maximum number of revolutions with the minimum amount of friction and power and with practically no wear. This situation exists so long as all conditions are perfectly balanced; but if the spindle base is filled with a mixture of dust, carbon, lubricating oil and various periodic injections of gasoline, the entire economic scheme is upset. No large efficiently operated plant would be able to exist under those conditions. No one could tell what the power requirements would be from hour to hour or from day to day. The output would vary, wear and replacements would occupy the attention of the mechanical personnel to the exclusion of almost everything else, the costs would rise out of all proportion and soon would absorb all profits of the operation.

The Motor-Oil Situation

The former work of the experts connected with the automotive and the petroleum industries indicated clearly that a petroleum lubricating oil of certain well-understood characteristics, having 180 to 190 seconds Saybolt viscosity at 100 deg. fahr., is the proper oil to use in an automotive engine when there is no dilution of the lubricant by the heavy ends of the fuel. At present, the viscosity of the mixture of fuel and lubricant being removed from these engines, as represented by the drainings from millions of engines, is less than 150 seconds Saybolt viscosity at 100 deg. fahr. If this viscosity represents a clear clean lubricating oil, it still would be very much thinner than should be used in the engines. The serious part of the problem is that the new oil now being used in the engines is nearly of the character formerly

used in the cylinders of steam engines, on stone crushers and on the heavy bearings of rolling-mill machinery. A viscosity of 800 seconds Saybolt at 100 deg. fahr., is not now considered an unusual oil for this work, and many of the engines are having oil put into them which has a viscosity of more than 1000 Saybolt seconds.

It is now considered desirable to allow portions of the fuel to mix with this very heavy oil, which eventually makes it thin enough in body to approach the theoretical need of the engine at some time during its operation. We thus have a remarkable condition of lubrication in all of our millions of automotive engines; it is that the heaviest oils the petroleum industry can produce commercially in the vast quantities needed for this important work are used admittedly for the purpose of forming a mixture in the lubrication systems of the engines with the leakages of the heavy ends of the fuel. The lubricating mixture in the engine, so far as its physical characteristics are concerned, undergoes a continual change during the first few hundred miles. It changes from the new bright-colored heavy oil first put into the engine to the thin black mixture of oil, fuel and dirt that must be removed at rather frequent intervals. But the unfortunate fact is that the oil is always allowed to remain in the engine after it has reached a condition which necessitates its removal.

Power Losses

It is well known that the use of heavy thick oil on any piece of mechanical equipment brings about frictional losses that generally, throughout a certain range, are proportional to the body of the lubricant. An engine that is being lubricated with the proper kind of thin oil suitable for the work it is doing may deliver as much as 20 per cent more power than when it is lubricated with a thick heavy oil.

The character and physical condition of the lubricant in the oiling system of the modern automotive engine is under no control whatever. It changes rapidly in viscosity throughout the range of all of the oils in the oil man's warehouse, including those from steam-cylinder oil to light bath-spindle oil. Nothing else in the entire history of the lubrication of machinery presents such a condition.

The Useful Life of a Lubricating Oil

An underlying principle, well understood by the Petroleum Technologists, has applied to the gradual evolution that has taken place in the methods of applying oils to industrial machinery. The former methods of application in no way exhausted the true lubricating qualities of the oil, and any petroleum oil could be made so that it was suitable for continuous service throughout thousands of hours in the proper kind of a circulating system in which it was used in a uncontaminated condition.

Oils have been produced that have been in active service in the circulating systems of turbines and engines for upwards of 10,000 hours without showing in any way that the lubricating qualities of the oil were reduced. In systems that are working at high temperatures and under severe conditions, there is a loss of oil due to a release of some of the lighter and more unstable portions that exist in any new oil, however it may be made and from whatever crude. In all systems this loss requires that a certain amount of new oil be added to the system to replenish the supply. The effect of using a petroleum lubricant in a ring-oiling bearing for several years without compensating for the natural loss of the lighter ends of the oil is to reduce the quantity of oil, make the oil of greater specific gravity, raise the fire and the flash points and increase the viscosity. There are other slight changes in color and in acidity. In fact, the used oil, compared with the new oil has actually improved itself as a lubricant for heavy work. These records have given rise to the statement that a petroleum lubricant cannot be entirely destroyed under usual working conditions. When a petroleum lubricant is used in an internal-combustion engine, it is treated in the most severe manner. Part of it is thrown up against the pistons where the temperatures are high enough to decompose every particle of oil immediately and leave only the carbon residue. In nature and in quantity, this is about the same as has been determined in the laboratory by the Conradson test. The portions of the oil which resist such temperatures as may be encountered have been relieved of all of the unstable and volatile constituents that exist in every new oil.

When a new oil direct from the refinery is put into the crankcase of an automotive engine, about one-half of it is completely destroyed. This is due to conditions which exist inside the engine and which cover a period that varies with different engines and different operating conditions; the other half of the lubricant remains. This surviving half is the result of a super-refining process which has taken place inside the engine and which has effectively eliminated all of the weaker parts of the original oil. The best and strongest elements have been consolidated and concentrated into a better and truer lubricant than it was before. The fact that this concentrated lubricant comes out of the engine in combination with portions of the unburned fuel, with carbon, road dust, metal particles and some water, in no way changes the further fact that the lubricant itself has increased greatly in value, for re-use in internal-combustion engines.

The reclamation or regeneration of used lubricating oil and its adequate preparation for re-use has been made a subject of intensive research during the last several years. There is now in process of establishment a new branch of the petroleum industry which will deal in special internal-combustion engine lubricants made from the selected stocks produced by the petroleum industry and which have been additionally refined by many hundreds of miles of use in automotive engines operated by the public. These highly concentrated lubricants are then subjected further to a quadruple refining process that again prepares them for use in the engines as de-luxe products which possess higher values than it is possible to secure in any other way.

ELY WHITNEY, AN APPRECIATION OF HIS LIFE

(Continued from page 5)

SKETCH OF WHITNEY'S LIFE.

Eli Whitney was born at Westborough, Mass., December 8, 1765. His father, a thrifty and prosperous farmer, was descended from an English ancestor who early settled in Massachusetts. His mother, Elizabeth Fay, of Boston was also of English ancestry.

In his boyhood, Whitney assisted his father in the labor of the farm and during winter months attended district school. His predilection for mechanical pursuits and invention was shown at an early age. When about twelve years old he made a complete violin. At this time his father proposed a collegiate edu-

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GEOLOGY

(Continued from page 28)

Professor Carl O. Dunbar spent the summer months in geologic field work in Nebraska and adjacent states where he was associated with Dr. G. E. Coudra, Director of the State Geological Survey of Nebraska, in an extensive study of the stratigraphy and faunas of the Coal Measures of that region. This work included a field conference with the Directors of the State Geological Surveys of Nebraska and Kansas which resulted in the detailed correlation of the Upper Carboniferous rock formations of Nebraska with those of Kansas and northern Oklahoma. During the latter part of the summer Prof. Dunbar was a councilor of the Third Annual Field Conference of the Kansas Geological Society and as such had the opportunity to extend the study of the Coal Measures rocks to their outcrops about the Black Hills, the Laramie Basin of Wyoming and the front of the Rockies in Colorado.

MECHANICAL ENGINEERING

(Continued from page 28)

in more ways than one. The man comes back a better teacher, a broader individual. His outlook upon the problems of his school is more mature and less provincial. Fortunate indeed is engineering education in general which can number among its teachers so many who have benefited from the experience of the summer school and fortunate the college whose faculty contains several men so trained."

Herbert W. Best, M. I. T. '21, instructor in Mechanical Engineering, attended the Saranac Lake Summer Meeting of the Society of Automotive Engineers and took part in the Mixture Distribution Conference.

Mr. Best reported how the mixture distribution in engine cylinders had been studied at the Mason Laboratory by analysis of the exhaust gases.

Professor H. L. Seward has been appointed Assistant to the President of the American Bureau of Shipping on a part time basis.

CIVIL ENGINEERING

(Continued from page 28)

First Vice-President; C. M. Blair ('04S), Secretary and Treasurer; and R. M. Hosley, ('00S), Assistant Secretary.

The Yale Engineering Camp was in constant use during the summer. In the six different courses offered there were 160 students enrolled, under twelve instructors. Professor Farnham was, as usual, in charge of the surveying courses. The following men assisted him in one or more courses; from the department, Professors Suttie and Eckle, Messrs. Allen, Allison, Gleason, Hughes, and Keith; also Professor F. J. Lewis of Vanderbilt University, Mr. W. T. Wentworth, and Mr. W. G. Geile ('19S) now of North Carolina State College. The courses given by the Yale School of Forestry were in charge of Professor H. H. Chapman, who was assisted in the survey work by Messrs. Hughes and Geile.

Professor Tracy, who was on leave of absence for the last half of the last college year, made an extensive tour in his automobile, accompanied by Mrs. Tracy. In the course of a fourteen-thousand mile drive which lasted from February until August, he visited and studied the civil engineering departments of fifteen or twenty of the larger universities on the Atlantic Coast as far south as Florida, in Louisiana, Texas, and Arizona and along the west coast from Los Angeles to Seattle. In addition he inspected many of the monumental engineering structures of the west, the Coolidge and Roosevelt Dams, the Apache Trail, the Columbia River Highway and some of the large new bridges in California and elsewhere. The tour included a side trip of 2300 miles by steamer to Alaska and up through the White Pass by railroad to the Klondike.

Professor Tracy has been appointed director of the summer school for engineering teachers which is to be held at Sheff. next year under the auspices of the Society for the Promotion of Engineering Education.

Professor Eckle spent the entire summer as resident engineer for the Springfield Terminal Railway Company, Springfield, Vermont, on the construction of foundations for a 160-foot steel bridge across the Black River.

Mr. D. F. Grant spent the summer on construction work in Hartford.

Two instructors have resigned from the department and two new men have been appointed in their places. Russell B. Allen ('23S) instructor since 1924, is now assistant engineer for the Boston and Maine Railroad, with headquarters at Boston, where he is associated with Howard E. Boardman (Yale '99S) Construction Engineer. W. H. Allison, who has been instructor for three years, is now assistant professor of civil engineering in Clarkson College, Potsdam, New York. The new appointees are Harold D. Hauf, who after having been graduated from the architectural engineering course at the University of Michigan has had engineering experience in architects' offices; and Robert W. Abbett, a graduate of Missouri University School of Mines, who has practiced municipal and civil engineering in Florida and Michigan.

CHEMISTRY

(Continued from page 29)

The death of Professor Frank Austin Gooch, '87 H. occurred at his home in New Haven, on August 12, after a prolonged illness. He was born at Watertown, Mass., May 2, 1852, the son of Joshua Goodale and Sarah Gates (Coolidge) Gooch. He received his early education in Watertown and later attended Harvard, where he received a B. A. in 1872 and an M. A. and a Ph.D in 1877 after mineralogical and crystalographic studies at the Imperial Museum in Vienna. He was given an honorary M. A. at Yale in 1887. He was assistant in the Chemistry Laboratory at Yale under Professor Josiah P. Cooke until 1875 and then studied with Professor Wolcott Gibbs and in Europe until 1878. He was engaged in analytical work at Newport for the United States Tenth Census from 1879 to 1881, as chemist on the Northern Transcontinental Survey from 1881 to 1884, and with the United States Geological Survey from 1884 to 1886. During this period he invented and perfected the perforated platinum crucible which bears his name. He had served as Professor of chemistry and director of the Kent Chemical Laboratory at Yale from 1885 to 1918 when he was made Professor Emeritus.

Professor Gooch was a member of the National Academy of Sciences, the American Philosophical Society, and the New York Academy of Science and was a fellow of the American Academy of Arts and Sciences. He had contributed papers to the *American Journal of Science* and to other scientific journals and was the author of numerous books on chemistry, including *Outlines of Inorganic Chemistry* and *Laboratory Experiments*, published jointly with C. F. Walker, and *Methods* in *Chemical Analysis.*

ELECTRICAL ENGINEERING

(Continued from page 29)

Professor Scott also attended the closing sessions of the Summer School for Engineering Teachers which was devoted this year to Mechanical Engineering and was held at Purdue University.

Professor Scott attended the Convention of the American Institute of Electrical Engineers at Swampscott and as Chairman of the Lamme Medal Committee announced the award of the Institute Medal to Mr. A. B. Field "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery."

Professor W. B. Hall spent the summer in New Haven continuing the development of conductively heated salt bath furnaces.

ELY WHITNEY, AN APPRECIATION OF HIS LIFE

(Continued from page 33)

cation for him and in 1783 he decided to prepare for college. He immediately reviewed all his studies and secured a position as teacher in the Town School of Grafton, Mass. At the appointed time he took charge of the school and gave such entire satisfaction that he was engaged for the following winter. With the money he earned he was able to attend Leicester Academy during the summer term. For five successive winters he taught school and during summer studied at Leicester Academy, where he prepared himself for college. In 1789 he entered the freshman class of Yale College. His work at college was creditable rather than brilliant; he left a marked impression behind him for good judgment, sound reasoning and steady intelligent work.

He graduated in 1792 and in the fall of the same year took up the problem of the cotton gin. His application for a patent was among the first made to the Patent Office of the United States. His creation of the cotton gin was fundamental and permanent, the same principle being used for that purpose at the present time. Eli Whitney's work endured. Two of his original factory buildings are still standing and are in good state of preservation. The Old Home and Armory Barn he built in 1816 are wonderful samples of permanent work. In 1817 he married the granddaughter of Jonathan Edwards and took up his residence in New Haven. His home, an old Hoadley masterpiece, is located at 275 Orange Street and has been recently restored. Here he died in 1825 leaving a widow and one son, Eli Whitney, 2d, at that time five years of age. Thus in a quarter of a century Eli Whitney established much that has survived. Timothy Dwight, President of Yale College, said of Mr. Whitney "He is a man who is rarely, perhaps never, exceeded in ingenuity, and not often in worth of every kind."

Both are lines *of* national defense

THE Mississippi was a menacing flood. The telephone was the first line of defense, for over its wires the work against the flood was directed. Maintenance crews performed the same service as did telephone men of the signal corps in the war.

In the daily life of the nation, just as surely as in emergency, the telephone meets an ever-growing stream of demands.

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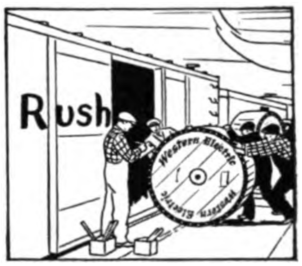
* * *

— and back of the lines stands the Western Electric *service of supply*

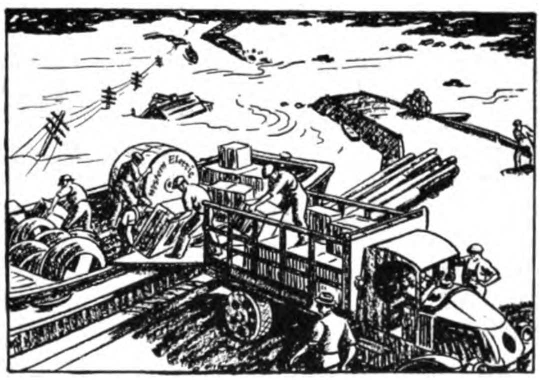
Men in the front lines of telephone service know they will always have the right tools and supplies when and where needed.

For Western Electric maintains stocks in a nationwide system of warehouses, and its prompt deliveries aid in repairing the ravages of storm, fire or flood. In the less spectacular, but equally necessary, everyday construction and maintenance of telephone lines, this service of supply is a dependable right arm.

And this is but one activity of Western Electric — manufacturers, purchasers, distributors for the Bell System.



Preparing the shipment is a matter of minutes



In the performance of these duties it either buys or makes virtually everything the telephone companies use—and then delivers to the job. Thus responsibility for the quality of materials with true economy in cost, is the important contribution which Western Electric makes as its share in efficient telephone service.

Western Electric sees it through with the material needs for promptly restoring telephone service

BELL SYSTEM

A nation-wide system of inter-connecting telephones

"OUR PIONEERING WORK HAS JUST BEGUN"

THE METAPHYSICS OF MODERN PHYSICAL SCIENCE

(Continued from page 22)

that of two canonically conjugate quantities, such as momentum and position, or energy and time pertaining to an atomic system not both can be known with perfect precision, not even theoretically. In fact it is possible to ascertain the necessary uncertainty in the determination of one if the precision of the other is known. If you know exactly the place of an electron you could essentially never know its speed. This marks perhaps the most striking departure of modern physics from old metaphysical doctrines.

Another one is more incidental but deserves at least to be mentioned. It concerns the kind of notions which constitute our conception of the physical world. To be quite noncommittal as to their epistemological status we shall call them symbols of explanation.

Classical physics selected for such symbols exclusively the elements of sense perception and combined them by imaginative processes which were always capable of visualization. Disregard of objectivity has caused modern theorists to feel more free in choosing their cosmic lumber; they have no longer any scruples in exploring the regions of abstract thought in their search for suitable symbols. Visual processes are still preferred, for they afford considerable convenience. But there are instances in which imagination does not suffice, in which an apparently solid structure of physical thought has been built up on the tenuous foundation of an equation insusceptible of physical interpretation in any direct sense. It is only in the simplest cases that the wave equation has meaning. An objection is likely to arise at this point, namely that in classical physics, too, momentous achievements have resulted from abstract mathematical laws that were difficult to interpret. It must be remembered, however, that the present state is different in this respect: the equations of classical physics, though not immediately transparent in all cases, were derived from observed facts which in turn suggested sensible experience. They contained measurable quantities while the wave equation is obtained as a consequence of abstract operations, defined in a formal manner, upon quantities of which the interpretation is uncertain, and which are at most statistically determinable. Furthermore, their meaning does not matter particularly, for physical significance is usually attached to accessory circumstances, such as conditions under which solutions remain finite, single valued, etc.

It is well to consider this matter from another point of view, since it is of strong metaphysical interest and involves the im-

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PERSONALITIES

(Continued from page 27)

anything but the hymn tune "Work for the Night is Coming". But you must know that when he does relax and puts on a first baseman's mit, for example, John Clayton is another individual. And he has a track record that his son Tom struggled hard and long to better. And the veneer of civilization isn't thick enough to conceal the fact that at heart he is a woodsman who could doubtless support himself indefinitely far removed from contact with his fellow men. Impelled by this primitive instinct he has every June for many years trekked with his family four hundred miles to the woods near Greenville, Maine, where he has a camp in the so-called "wild-lands", some miles from the little town, in the heart of the primitive wilderness, with denizens of the forest for daily companions. Here, when he and his good wife have not been dispensing gracious hospitality, he has spent his mornings on the book and his afternoons on the brook. It is creditably stated that the Tracy family never start to take a load of provisions, cows, and other farm animals across Lower Wilson Pond in one of their fleet of speedy power boats without the Professor's first seating himself on a log, properly supported at distances of 'x and x' from its respective ends, and carefully figuring dead load, live load, maximum and minimum shear, and bending moment, positive and negative. Last of all he sketches a diagram of influence lines, if any. The whole is then computed by the algebraic method (Cases I, IV and VI) and checked by the graphic method (Arts. 20 and 39). Then and then only does he venture to embark. On the way over he always enlivens the company with diverting tales of the salmon he corralled in this self-same pond in 1900 or thereabouts, after a struggle from dawn to dark, and whose weight and height have ever since acquired infinitesimal annual increments.

In 1894, Professor Tracy married Elizabeth Mary Blakeslee, (Wellesley 1891), daughter of the Reverend and Mrs. Erastus Blakeslee of Brookline, Massachusetts, and they have three children, all grown and married, namely John Blakeslee, Yale 1918, Thomas North, Yale 1925 S, and Delia Elizabeth (now Mrs. Carleton Goodyear Smith), Wellesley 1927. It is common knowledge that the serene happiness of the Tracy's married life is due to the methodical method by which the professor made his choice. He first put into Wordsworthian or Byronic verse certain exacting requirements for an ideal helpmeet (*vid.* the 1890 S. classbook) and he shortly thereafter discovered, in the person of the minister's attractive daughter, the young lady who more than met the specifications.

Professor Tracy taught surveying to large classes, as others had done before him, along the New Haven sidewalks, in the vicinity of Sheff, under conditions far from ideal. That the School has now at East Lyme an engineering camp second to none is due in large part to his farsightedness in securing the necessary land.

Of late years Professor Tracy's extra-curricular activities have been multitudinous and varied. An enthusiastic Kiwanian, and ex-governor of the New England District, he is slapped on the back and called by his Christian name every Wednesday from 12:15 to 1:10. As director of the New Haven War Bureau from January 1918 to May 1919 his talents as an organizer were widely recognized. For two years, 1926 and 1927, he was president of the New Haven Chamber of Commerce, after having served for years as a director. During his regime the

activities of the Chamber were extended and the unique and eminently successful "Progress Exposition" was undertaken. He has been Yale representative on the Sigma Xi National Council. In the formative years of the Yale Engineering Association he served on its executive committee. He is secretary of the class of 1890 S. He is also a member of the Aurelian Honor Society, of Tau Beta Pi, and of the American Society of Civil Engineers.

THE METAPHYSICS OF MODERN PHYSICAL SCIENCE

(Continued from page 38)

portant question of method. Scientists have always felt and still feel that nature can be described in terms of mathematical analysis; no change has come in this respect. Yet it is common knowledge that a fact expressed mathematically never agrees exactly with experience. Classical physics was inclined to attribute the discrepancy to unavoidable faults of experimentation, whereas the modern attitude recognizes also some flaws and inadequacies inherent in mathematical representation. But that is a minor point of difference. On the whole mathematics has seen its prestige increased and its field of application to physics considerably widened. A well ordered theory in Newtonian physics required three things: experimentally established facts, a set of consistent symbols of explanation, and some portion of mathematics by means of which those symbols could be handled. Theoretical investigation was the process of combining the explanatory symbols according to logical principles, which was greatly abbreviated and made more dependable by mathematical formulation. Analysis without corresponding symbols (time, space, masses, electrons, atoms, etc., the latter conceived on a definite plan) was meaningless. Now it has already been stated that in quantum mechanics formal mathematical concepts or relations have themselves become symbols of explanation, which eliminates one of the three requisites. Nothing is left beside perceptual facts and mathematical formulation. A theory is good if the latter leads to the former, even though the point at which the reasoning starts, may be obscure and arbitrary. A striking example of this peculiar self-consistency of a mathematical method is afforded by Dirac's new theory of the electron. Its analysis begins with an equation of somewhat doubtful origin—it is derived from the relativity wave equation in a way that is plausible but lacks logical constraint—and develops in a most amazing fashion just those features of the electron which had been so difficult to understand, its magnetic moment and its moment of momentum. A procedure as formal as this has decided advantages. On the other hand it is open to severe criticisms: if an analysis has no extra-mathematical descriptive background, is it not likely to become indiscriminative and vague? One equation may correspond to numerous different physical facts, its requires additional information to know its meaning. Gravitational mass, magnetic bodies and electric charges are alike in those respects which find their expression in Coulomb's Law, but this law would leave us in ignorance of the fact that they have otherwise very different physical properties. With the shift of emphasis from content to form of mathematical method, which has occurred in modern physics, there has come a danger of over-estimating formal analogies and of misjudging distinct physical situations as identical if they are reducible by the same mathematical analysis. But on the whole the practical successes of the quantum theory are so overwhelming that metaphysical difficulties seem almost insignificant.

ELECTRIC LIGHT'S FIFTIETH ANNIVERSARY

(Continued from page 14)

The Multiple System of Distribution.

The electrical engineer sees in Edison's establishment of an electric lighting plant in New York in 1882 much more to laud than merely the perfection of an incandescent lamp. All the previous lighting had been by arcs on a series circuit,—the current constant and the voltage adjusted to meet the resistance of the circuit and the lamps disposed along it. Home lighting was out of the question with such a scheme because the lamps could not be rendered independent of one another, they were too intense and the circuit voltage was too high for safety. The sub-division of the electric light had been declared physically impracticable by no less an authority than Sir William Preece, director of British telegraphs, because his experiments satisfied him that the total light obtainable from several paralleled arcs fell off as the cube of the number employed. He failed to sense the effect of drop in terminal voltage of his battery when subjected to the increased draft of current. But Sir William Thomson, J. W. Swan and Professors Morton, Tyndall and Siemens sided with Preece with none to come out for Edison. Edison proceeded to prove the feasibility of the multiple system by installing several plants on steamships, in mills and private residences. Before the New York Station was opened (September 4, 1882) 80,000 lamps had been sold and 50,000 more were in stock.

He met the argument of intolerable voltage drop in the multiple system by devising the feeder and main system which employed mains of ample conductivity to keep the voltage range at the lamps restricted in amount, the drop in the feeder from the plant to the mains being compensated for by adjustment of the voltage at the generator. Then later he cleverly devised the 3-wire system which superimposed on the advantage of line losses decreased as the square of the voltage the added opportunity to operate motors across the 220 volts between "outside wires". The 3-wire system still rules for all metropolitan D. C. distribution and is extensively resorted to in A. C. distribution at the lower voltage. Edison reasoned that 220 volts would be better than 110 volts just as 110 volts surpassed in circuit and lamp performance the lower voltages aimed at in the early incandescent lamp efforts. The 3-wire scheme incorporated this superiority but retained the better efficiency and economy of the 110-volt filament lamp as compared with the 220-volt filament lamp.

Incidental Difficulties.

Edison did not invent the dynamo. But he found that those which were available did not qualify for his service. Barlow (1823), Faraday (1831), and Pixii (1832) had established the foundations of the dynamo and Brett (1848) had proposed the self-excitation of the magnetic fields. But most of them had poor efficiency. The physicists who developed them were cell-minded because of their previous dependence on voltaic cells for electrical supply. They had established the principle that that maximum current efficiency was obtained when the cells were so grouped that the battery's internal resistance was equal to the external circuit resistance. Again Edison was ridiculed when he proposed a generator that would have 90 percent efficiency. The distinction between maximum current efficiency in a series circuit and of high energy efficiency in a multiple circuit was clear to Edison but he was practically unsupported. Further than that the largest generator available had a fifty-lamp rating, equivalent to some six horsepower. Expansion in size

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ELECTRIC LIGHT'S FIFTIETH ANNIVERSARY

(Continued from page 42)

to a rating of several hundred lamps presented more problems and ended in just one more big accomplishment that should not be overshadowed by the development of the lamp.

Electrical energy distribution was unknown and the underground installation of conductors called for development of the ducts and of conductors, junction devices, insulators, meters, switches, and sockets for the lamps. All these had to be brought to workability before a central station installation could be undertaken. But on September 4, 1882 the Pearl Street Station in New York was put into service. Initially 400 sixteen candle-power lamps were served in the area between Wall, South, Nassau and Spruce Streets. By November 1883 the connected load was 55,000 lamps. Meanwhile Edison systems were being installed all over this country and several in Europe.

The Edison Accomplishment.

Eight decades of scientific discovery had preceeded Edison's energetic entrance into the field of electric lighting. Phenomena and principles had accumulated but no one had had the vision to assemble the significant steps into a pattern that would release electricity from its fetters and apply it to the light and power service of mankind. Edison had this vision, a keeness of intellect to discern the handicapping factors and short-circuit them. An unusual intellectual courage enabled him to stand his ground in the face of all disparagement and ridicule. He had a more comprehensive grasp of the potentiality of the electric incandescent lamp than the best minds of his day and a clear picture of the problem from the generator to the last lamp on the lines.

The electrical industry is making much of the celebration of the fiftieth anniversary of the incandescent lamp because it marked the emergence of electricity from the realm of the laboratory to the arena of public service. And along with it goes a sincere testimonial to the practical physicist who integrated a mass of differentials into a unified system which was the forerunner of today's ten billion dollar power system.

THE SIGNIFICANCE OF ELECTRIC LIGHTING

(Continued from page 20)

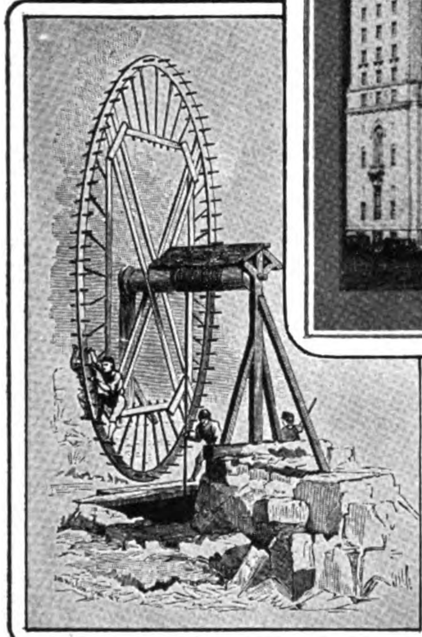
Several years ago I looked across the New Haven green one rainy evening and saw the lighted shop windows. The arc lamps had hoods which directed the light down. The buildings above the first floor were invisible. On another street in front of the City Hall were lamp posts with tungsten lamps in spherical globes. The whole front of the building, with its noble architecture, was distinctly visible. It was in pleasing contrast to the gloomy appearance above the shop windows on the other street. A transformation came with the pioneer installation of "White Way" lighting in New Haven.

And so we might examine an unending list of the things that make up our modern life. Practically every one is dependent in one way or another on light.

At first a luxury, the electric light has become essential to efficiency, safety, comfort and happiness. It is one of the most potent aids to the artistic and the esthetic. It is an indispensable factor in our new methods of living and is interwoven with the fabric of our new civilization.

THE ROYAL YORK HOTEL, TORONTO, CANADA

Ross & MacDonald, Architects *Sproat & Rolph, Associate Architects*



Reproduction of an old wood-cut showing one of the early phases of Vertical Transportation

The Tallest Building in the British Empire

THE new Royal York Hotel, Toronto, Canada, is the British Empire's tallest building and its largest hotel. This immense structure embodies modern improvements throughout and particularly in regard to Vertical Transportation, which is provided by seventeen elevators of Otis-Fensom manufacture. Ten of these are Otis Signal Control elevators, and the remainder are equipped with Otis "Flying Stop" control.

Here again is found proof of the saying that "most of the world's famous buildings are Otis-equipped."

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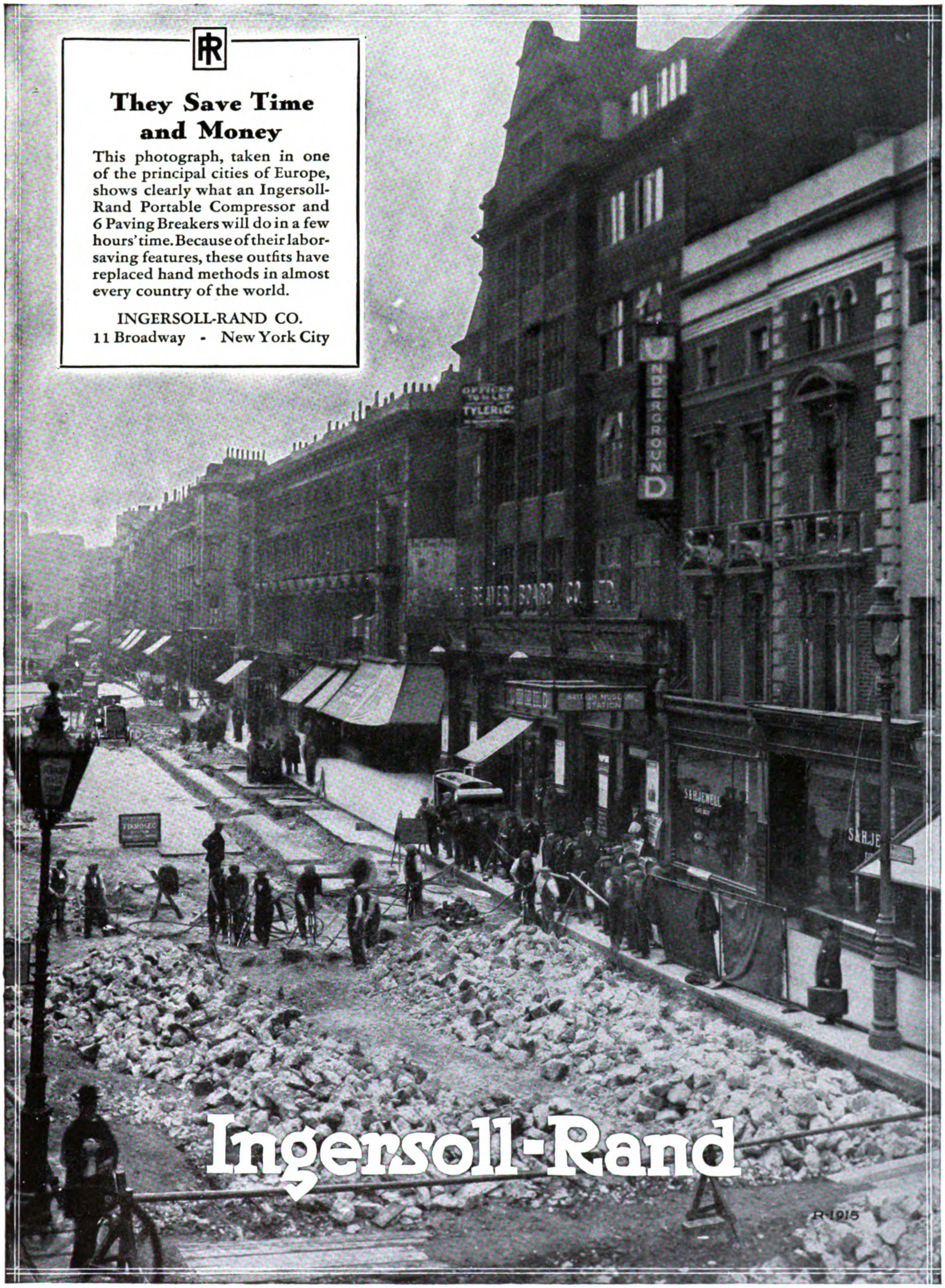
OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD


IR
They Save Time and Money
This photograph, taken in one of the principal cities of Europe, shows clearly what an Ingersoll-Rand Portable Compressor and 6 Paving Breakers will do in a few hours' time. Because of their labor-saving features, these outfits have replaced hand methods in almost every country of the world.
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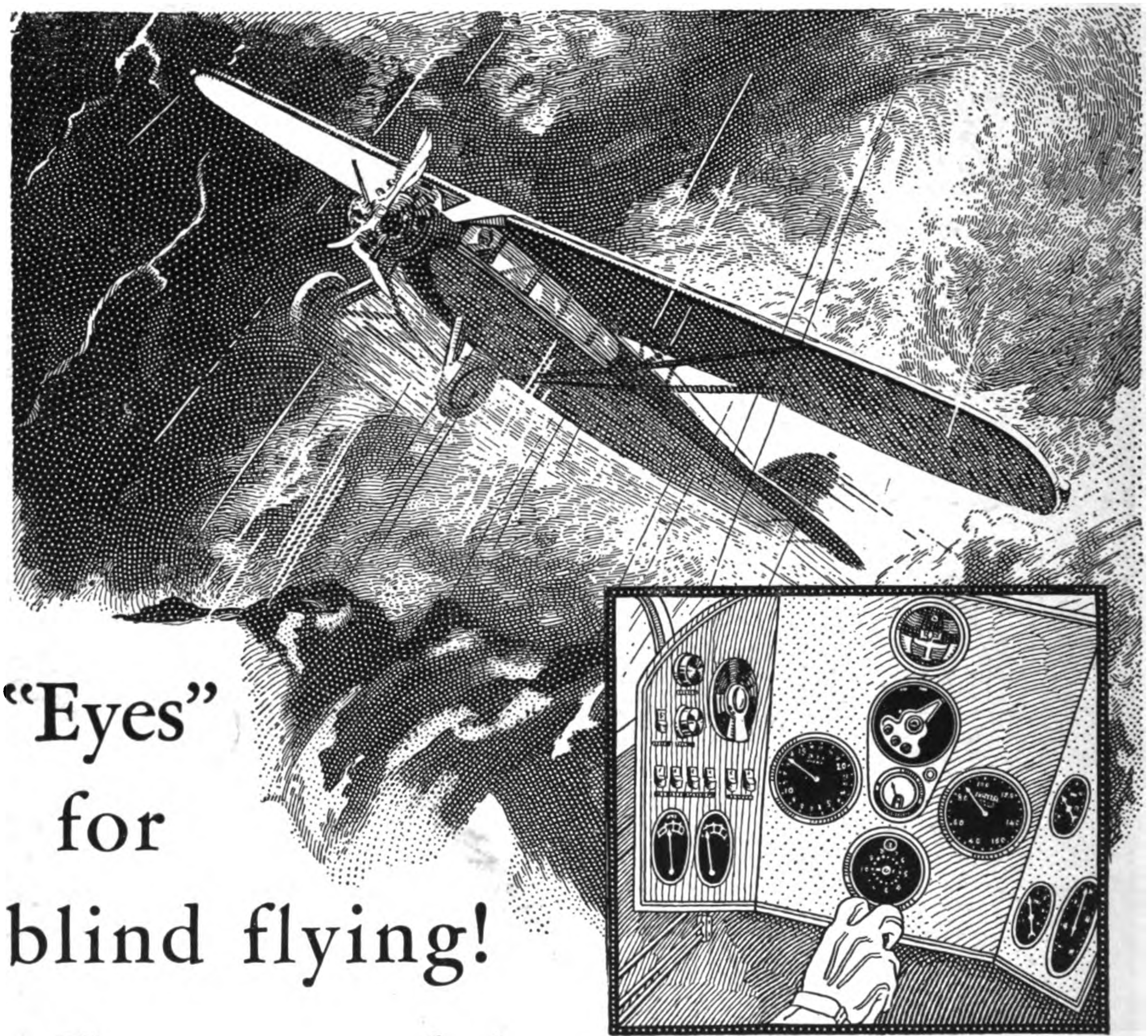

THE YALE SCIENTIFIC MAGAZINE

VOL. IV JANUARY, 1930 No. 2

PRIMATE LABORATORIES OF THE PASTEUR INSTITUTE AT KINDIA, FRENCH GUINEA.

(See page 9)

PUBLISHED QUARTERLY IN THE INTERESTS OF SCIENCE AND ENGINEERING IN THE SHEFFIELD SCIENTIFIC SCHOOL

THE YALE SCIENTIFIC MAGAZINE

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THE tendency of the undergraduate is to reflect the belief, which is held by many who are not in direct touch with the engineering profession, that the field for engineers is more or less saturated and that the young engineering graduate will find no place for himself. In this connection we present the following statement by S. S. Board, director of the Yale Graduate Placement Bureau:

"The comparative shortage of recent engineering graduates is a matter which should be known not only to those now in Sheff. but should be passed on to those still in preparatory school. It has been a tradition for so long that the country was full of starving engineers that it seems difficult to realize the tide is turning. The Yale Graduate Placement Bureau reports, however, that while the starting pay is about what it is in other business occupations, the demand for beginning engineers or those out from one to three years has been four to five times the supply for the past year.

"A considerable part of the demand has been for those with a B.S. in either Electrical or Mechanical Engineering but in addition to what might be called these straight engineering jobs, there have been calls for men with an engineering background for factory operations, for sales opportunities of various kinds, for work in the banking field and for other general business activities. Business seems to be looking for the engineering viewpoint and background and to be more willing to pay for it than heretofore. Coupled also with this desire for the engineering background is an insistence that such men be able to mingle with other men, to understand their problems and to lead them in productive processes, and it may well be that the fact that Yale has laid more emphasis on the humanities and does give a broader course has increased the demand for men from Sheff.

"It seems to be at any rate a question which freshmen and those still in prep school should give serious consideration. There are aspects of culture, especially modern culture, which can only be found in a scientific education and when one is in a position in which it is necessary to consider work as well as the cultural side of life in securing an education the present demand for engineers in all phases of business should be reckoned with, along with such factors as the social and extra-curricular side of University activities, the need to work one's way through, the broadening influence of cultural courses and the contact with one's instructors.

"It is especially important at the present time that it be considered by those about to choose their college courses because this demand has not reached its ascendancy and those entering Yale next year or the year after ought to be able to profit by it. We have, of course, fluctuating demands for men in all lines of work but the tragic thing about it is that the supply coming out never jibes with the demand. If, therefore, we can get these two curves nearer together and can help to bring about a supply nearer to the time of demand, it should be mutually profitable—profitable to the employer because he gets help when he needs it most and to the employee because he is better able to secure an adequate wage and a real opportunity."

Progress in Automatic Train Control

Recent Developments which Helped to Make Railroads Safer and Transportation Cheaper.

By Prof. S. W. Dudley

ECONOMICAL and rapid transportation has been perhaps the most potent single factor in the extraordinary material progress of the last few decades. The railroads constitute the circulatory system of our material prosperity, bringing the raw materials to industry, and distributing its products throughout the length and breadth of the land. Transportation achievements are measured in terms of speed and tonnage, which, in turn, are usually thought of as dependent primarily upon the motive power available. Seldom is it realized that the fastest and most powerful locomotive would be worse than useless without adequate means for safely and conveniently controlling the energy which it is capable of developing.

Consider for a moment the extraordinary advances made in the transportation service of our railroads during the past nine years.* For the period, 1920 to 1928, inclusive, the volume of traffic handled by the railroads of the United States increased 21%. This was accomplished by increasing the total train loadings by 26.7%, and running these trains at an average of 18.3% higher speed, with an increase in the average tractive effort of the locomotives used of only 19.5%. As a result, the total train miles decreased 5%; the total number of hours of train movement was reduced by 23.9%, and the locomotive miles by 5.3%; with an overall saving of 11.8% in fuel. This remarkable record illustrates the effect of careful management, close supervision and the utilization of every possible advantage offered by technical and engineering developments that affect the carrying capacity and the speed of train movement. These savings have been reflected in actual costs to the shipper. In 1921 he paid the railroads, on the average, about 1-1/4 cents for handling a ton of freight a distance of one mile, while in 1928 his ton of freight was carried by the railroads a distance of one mile for almost the cost of a one cent postage stamp (1.081 cents).

Speed of train movement, in this case, does not mean reaching the highest attainable maximum speed for a very few selected trains, either passenger or freight, but a higher average, achieved by greater uniformity of traffic movement as a whole. It has been clearly demonstrated that the carrying capacity of a given section of track is increased more by greater uniformity in train speed than by any other one factor. This depends upon reducing the number of stops, slow-downs, delays and potential operating hazards which limit the safety of operation.

In other words, the capacity, as well as the safety, of railroad traffic is conditioned primarily upon safe and responsive control.

In the early days of railroading, and until well beyond the middle of the last century, this control was entirely manual. When the engineman desired to make a stop, he blew a signal and the brakeman set the hand brakes on the cars as best they might. This served to permit trains of moderate length to run at moderate speeds, but it was soon recognized that for safety and effectiveness the control of the train must be placed in the hands of the man responsible for its operation, namely, the engineman.

Several ingenious forms of mechanically operated continuous brakes were developed and used extensively on some of the larger railroads during the period from 1840 to 1870.

It is of interest to note, in this connection, that Willard Gibbs, in 1866, three years after taking his Doctorate at Yale, was granted a U. S. Patent (No. 53971) for a buffer type of brake for railroad cars, its object being "to dispense with brakemen. All the brakes in the train are to be simultaneously applied by the momentum of the train when the speed of the locomotive is checked and the brakes thrown off when the locomotive is started or the usual speed resumed."

The advantages of a continuous brake were self evident and imperative, but the mechanical systems employed were so erratic in action that they quickly disappeared when the simpler and more dependable pneumatic brake was introduced in 1869.

The first form of air brake was non-automatic, that is to say, a failure of the system would prevent the engineman from applying the brakes on the train. Within two years this serious deficiency was overcome by the invention of the automatic air brake which remained charged and ready for action during normal running periods, so that any failure of the piping or connections between cars would cause the brakes to apply automatically. In this way a flexible, responsive and reliable means for controlling the speed of the train was placed at the disposal of the engineman, together with automatic protection against a failure of this means of control.

The mechanism provided for this purpose was ingenious and complicated but at the same time effective and dependable. Subsequent developments up to the present day have increased its reliability and effectiveness so far as the braking means are concerned, but it is to be noted that the system is not self-actuating except in case of actual damage to the system itself. For all normal operations it must be actuated by the engineman according to his understanding of the circumstances confronting him, and his judgment as to how best to meet these requirements. Train orders, signal indications, and observation convey to the engineman the requirements of ordinary train movement. By the use of automatic block signals a maximum amount of information and protection is provided, so long as circumstances, such as weather conditions, do not interfere, and the engineman is competent, careful and alert.

There are times, however, when weather or other conditions render it difficult and perhaps almost impossible for the engineman to see the ordinary signal indications readily enough to maintain the desirable speed of his train. Furthermore, he may become incapacitated or temporarily distracted so that his response to the signals is not what it should be. For such cases, some provision for automatic control of the train would not only safe-

*"Trains of Tomorrow," L. K. Sillcox, Traveling Engineers' Association, Chicago, Ill., Sept., 1929.

guard life and property, but permit the maintenance of higher average speeds and greater uniformity of speed, and thus contribute materially to the capacity and economy, as well as the safety of traffic. The automatic train control system is designed to serve these major purposes. It can be arranged to stop the train automatically, or to reduce its speed, if the engineman is unable, or fails, to act according to the signal indications; or to convey to the engineman suitable audible or visible indications, within the cab, as to the condition of the signals and track, so as to enable him to exercise proper judgment in controlling the train, or both.

One of the very earliest methods of accomplishing such an automatic control was the use of a glass tube projecting above the locomotive cab and connected to the piping of the air brake system in such a way that if the locomotive passed a signal set at danger, the glass tube would be broken by a projecting arm from the signal, and the brakes set automatically. While crude, and not used to any considerable extent, this illustrates the essential elements necessary to the operation of all automatic

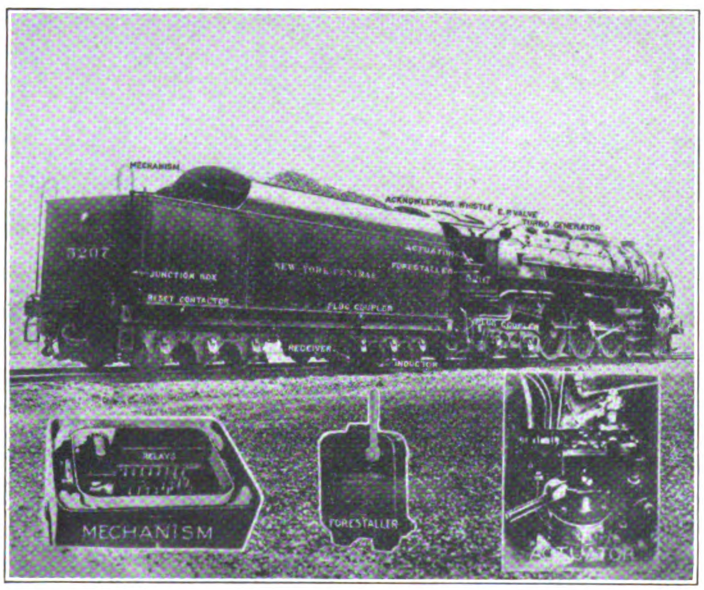

Fig. 1. Locomotive equipped with automatic control. Inserts show mechanism, forestaller and actuator.

train control devices. There must be a roadside element of some sort, responsive to signal indications or track conditions which are to be observed by a corresponding train movement. On the engine there must be a receiver, responsive, either by physical contact or electric induction, to the indications transmitted by the roadside element. This receiver on the engine must transmit the impulse received to a suitable actuating mechanism which will cause the controlling apparatus on the train to function and produce the desired conformity of train movement.

As a result of the steadily increasing demand for safety to life and property, and governmental supervision of the agencies required to bring this about, Congress in 1906, instructed the Interstate Commerce Commission to investigate the subject of automatic train control, block signals, etc.* Investigations and reports followed until in 1920 the Transportation Act gave the Commission authority to order the installation of train control and undertake suitable investigations. In January, 1922, the first order was issued by the Commission, requiring 49 railroads to install train control on a complete passenger division. In January, 1924, following discussions and numerous extensions of the preceding order, a second order was issued requesting 47 of the original 49 railroads to proceed with installations. Various exemptions and extensions followed, but as a result of this legislation the work of selecting types of train control apparatus and installing these systems went forward rapidly. The Commission laid down specific requirements as to functions, and general requirements, design, construction and operation. Many systems were proposed but out of a total of 17 devices listed by the Train Control Committee originally, only 7 were considered worthy of physical installation and 5 of these have since been materially changed.

*See "Automatic Train Control," G. E. Ellis, Paper before the A. S. M. E., Washington, D. C., October 19, 1928.

The various systems proposed, considered or actually installed have been classified broadly—

(A) According to the methods of communication between the track and train elements or—

(B) According to the chief characteristics of their operation.

The train may be under *intermittent* control, i.e., subject to indications from the track only at certain definite points (usually at signals) between which points the indications thus received normally remain the controlling factor; or *continuous* control with which the train is, in general, always under the influence of the train control system and subject to indications that may be transmitted to it at any point. This control may be accomplished by physical *contact* between the roadside and the train elements or, in the *non-contact* type, by bringing the train element into some kind of inductive relation with the roadside element. The various types of these classes of systems are distinguished by the form of elements employed as indicated by the following classification:

CLASSIFICATION OF AUTOMATIC TRAIN CONTROL SYSTEMS—ACCORDING TO METHODS OF COMMUNICATION BETWEEN TRACK AND TRAIN ELEMENTS.

Character of Control	*Class of Device*	*Type of Device*
I—Intermittent	A—Contact	1. Plain mechanical trip ground or overhead. 2. Electrically controlled mechanical trip, ground or overhead. 3. Intermittent electrical contact (Ramp) (6.7 per cent).*
	B—Track-rail contact	1. Insulated truck with short track-circuits section (52.8).*
	C—Non-contact	1. Induction. 2. Inert roadside element. 3. Non-magnetic rail.
II—Continuous	A—Contact	1. Third rail or special conductor.
	B—Non-contact	1. Induction (40.5 per cent).* 2. Wireless.

*The percentage figures above indicate approximately the relative number of installations of the types designated that were in actual service in the latter part of October 1928. Types not designated are not in regular service on steam railroads.

The systems which have been put into actual service by railroads, considered from the standpoint of their characteristic effect on train operation, may be classified in four main groups.

The *automatic stop* of the *intermittent* type with cab signals and a forestalling device, which permits the engineer to acknowledge the signal indications and proceed within predetermined limitations; the *automatic stop* of the *continuous* type, also with *forestaller;* the *speed control* of the continuous type with cab signals, and the continuously controlled *cab signals* without automatic brake applying devices.

CLASSIFICATION OF AUTOMATIC TRAIN CONTROL SYSTEMS ACCORDING TO OPERATING CHARACTERISTICS.

(A)	Automatic stop, with forestaller.	(1)	Continuous with cab signals.
		(2)	Intermittent.
(B)	Speed control.	(1)	Continuous with cab signals.
(C)	Cab Signals only.	(1)	Continuous.

In the above the cab signal without automatic brake applying equipment is included as an automatic train control device for the reason that the continuous system of cab signalling has all of the control elements essential in a train control system except for the automatic feature of providing against the incapacity or gross carelessness of the engineer. The operating advantages and increased safety of continuously controlled cab signals for adverse weather and track conditions constitute essentially an automatic device permitting the engineer to control the train in accordance with actual requirements to a degree that would be wholly unattainable without them.

Generally speaking, the ideal train control system will have to function first to provide information by which the engineer can handle his train properly and second, to stop the train automatically or reduce its speed in accordance with a predetermined retardation curve, if the engineman is unable or, for any reason fails, to handle his train safely.*

All of the types of devices indicated in the classifications above have been tried out, experimentally at least. The plain mechanical trip has been used quite extensively in subway and elevated service to provide a positive stop when the train is running by a danger signal. For elevated or subway service where the right of way is protected the system works very well, but both the plain mechanical trip and the electrically controlled mechanical trip are seriously interfered with by weather conditions, the lack of uniformity which exists in steam road equipment, and the possibility of interference by trespassers. They were the first types to be adopted to any considerable extent in actual service.

The intermittent electrical contact type using a ramp has been installed on two important railroads, but as shown by the percentages given above, they found far less favor than the non-contact induction type of communication from track to train. Essentially, the ramp system consists of a short section of rail alongside the track outside, or a little higher than the top of the running rails. This ramp is energized from a roadside battery using either one of two polarities, thereby providing the required different indications according to the signal position. A shoe carried by the engine, coming in contact with this ramp, operated the necessary intermediate mechanism to cause an application of the brakes either by electrical means or mechanical connection to the air brake system. The apparatus is so arranged that current must be present in order to permit a clear indication to be given on the locomotive so that any failure of the roadside or communicating system may be on the side of producing a stop rather than permitting the train to go forward into what may be a danger zone.

The advantage of the induction type of apparatus is in the absence of any actual contact between the train and roadside elements. There are several types, some using an inert roadside element, others subject to current flow from a roadside source of energy controlled by the signal apparatus.

In the system using an inert roadside element a coil mounted in a non-magnetic casing is secured to the ties outside of and parallel to the rail. The winding of the coil is connected to the signal system in such a way that when the block is clear the circuit is closed and when the block is occupied the circuit is open. The engine receiver coils are energized from a source of current on the locomotive, these current values being affected when passing above, but not in contact with, the inductor, depending upon whether the inductor circuit is open or not. The

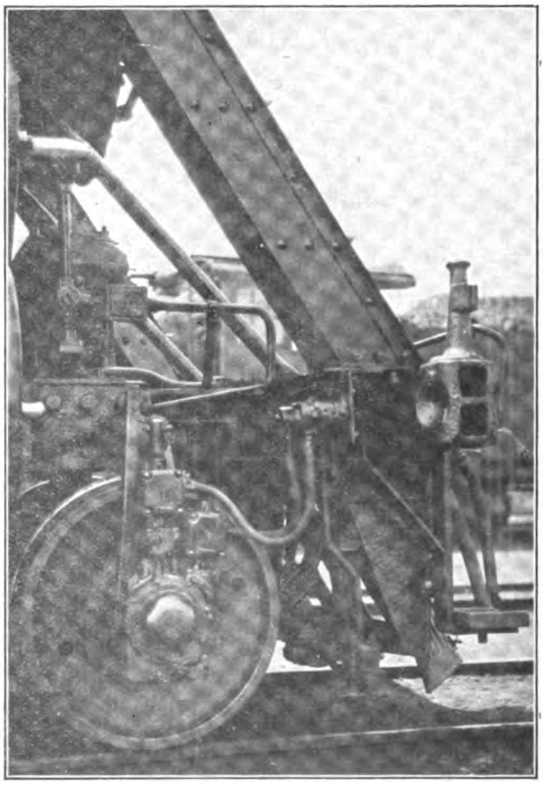

Fig. 2. Locomotive truck, showing automatic centrifugal speed control.

variations in the receiver coil current are translated by a suitable electro-pneumatic mechanism into the proper brake action.

The other induction type employs permanent bar magnets between the rails, the field of these magnets being subject to variation according to the current allowed to flow through coils mounted with the bar magnets and subject to a roadside source of energy controlled by the signal apparatus.

The transmission and amplification of the electric impulses picked up by the receivers on the locomotive utilizes many of the principles and types of apparatus which have been developed in connection with radio circuits. The actual application of the brakes is accomplished in various ways, either by a simple electro-pneumatic valve controlling a valve device designed to perform the same function as the engineer's brake valve when manipulated in the ordinary manner, or by a mechanism for automatically

(Continued on page 36)

*"What is the Future of Train Control," F. H. Nicholson, *Railway Signalling*, June, 1929, Page 220.

Presenting the Case for the College

The College Offers a Liberal Education in The Arts or Sciences, Better Social Advantages, and The Atmosphere of The Old Yale Traditions.

By Louis W. Ladd, Jr. 1930

LATE in March, the already bewildered freshman is presented with another bewildering question—one that must be decided within a few months and one that affects his whole college career tremendously. This question,—whether to finish Yale in the College or the Sheffield Scientific School,—must be decided individually, of course, with serious consideration of just what the individual expects to get out of Yale. If one wants a scientific education and wants it immediately, the obvious thing to do is to enroll in the Scientific School. Account must be taken, of course, of those who know what they wish to do and who wish to prepare for it. Those, for instance who desire to teach—be it English, history, or language—are naturally directed to the College. There is, however, no problem of College or Scientific School in the minds of those whose careers are planned. On the other hand, if one is undecided as to what he does want and doesn't know what his life work is to be, the College seems to offer more advantages than the Scientific School.

In the November issue of the magazine we outlined a new policy—that of publishing articles by undergraduates on Sheff problems. One of the primary problems in the underpopulation question, which, of course, arises from the swing in recent years of the freshman classes towards the College. Mr. Ladd is a prominent senior in the College. His discussion here should accurately reflect the opinions of the undergraduates in the College on the subject of the Freshman's choice.

First of all, the College offers distinct advantages in a scholastic way. There are two main courses of study, the General Course and the Honors Course, both of which offer the degree of Bachelor of Arts or Bachelor of Philosophy. The General Course is primarily for those wishing a liberal education in the Arts with no idea of specializing beyond the required subject. The Honors Course is for those wishing an education in a specialized field, undertaking a more comprehensive and intensive study in that particular field—be it history, art, chemistry, language, or what not To be sure, the General Course requires a major subject, progressives, and group requirements. Yet the choice here is free enough to enable the student to study the majority of subjects he desires. The main object of this course is to give a liberal and not specific education in the Arts.

The Honors Course, on the other hand, requires a certain scholastic standing and is planned out with the student by the department heads of that branch of learning in which the student wishes to specialize. Yet in both cases the choice is more varied than in the Scientific School. The College offers choices in both science and the arts, whereas the choices in Sheff. are patterned on certain fixed lines such as Industrial Engineering, Chemical Engineering, Electrical Engineering, and the like. The College offers many elective courses, Sheff., very few.

The majority of men, if they wish to specialize and have the time and means to do so, prefer a liberal foundation for their future graduate work. And those undecided as to what they plan to make their life work will find a background of the arts a greater aid than a more narrow education in a limited field. Coupled with this is the advantage offered by freedom to choose inspiring professors in both the College and Sheff.—an opportunity which goes along with the more numerous electives offered in the College.

Socially, the College has more to offer than Sheff. All of the old Yale atmosphere seems to hover over the Junior Fraternities and Senior Societies. This is best illustrated by the colorful traditions of Calcium Night when the Junior Fraternities march about the campus robed and carrying various colored flares and singing their respective songs. "Calling" and the "horseplay" of the candidates also lend atmosphere. Then there is the glamor and mystery of the secret Senior Societies and Tap Day every May when the whole Junior Class gathers under the elms on the campus and sixty lucky men are tapped and told, "Go to your room."

The beauty and comfort of such buildings as Harkness, Bingham, and the other College buildings are not to be paralleled in Sheff. For the housing of non-fraternity men in Sheff. is a serous question, whereas all the Seniors, Juniors, and Sophomores in the College have adequate and comfortable dormitories.

And yet the choice of the College or Sheff. depends entirely upon the man and what he desires. Perhaps he goes to the college because his father went there—or again he decides on Sheff. because his brother made a club back in '03. Then again Sheff. has the reputation for being hard—Ac is easier, so he picks the easier school. One must have leisure, you know. Culture's the thing—come to the College and be cultured—go Sheff. and be a hard-working practical scientist. In any case one must have a college education in order to sell bonds successfully.

Apes as Instruments of Human Progress

Yale is Organizing a Concerted Attack on Major Problems of Human Behavior by the Use of the Chimpanzee Colony on Prospect Street.

By PROFESSOR ROBERT M. YERKES

"FOR the last five years Yale has maintained secretly an anthropoid colony at the University. Dr. Angell did not explain, but it appears likely that public prejudice was the outstanding cause for the secrecy. It is unfortunate that misinformed persons persist in referring to valuable experiments of this nature as quests for the 'missing link.'" (Washington Post, September 5, 1929.) This news item I take as my text. The news writer's explanation is perfect, however little the members of our all-too-popular colony of chimpanzees on Prospect Street coöperated in maintaining "secrecy"! Such barriers as have been set up about the Primate Laboratory for the protection of our animals and our work were rendered necessary by the careless acts of over-curious juvenile visitors. Without thought of secrecy we have sought freedom and security in the conduct of our investigations. It is true we do not court publicity, for too often it results in misunderstandings, unenlightened criticism, or still worse, in ridicule. If rats or guinea pigs were our experimental subjects, we should be neglected by all save our scientific brethern.

Why are apes in Yale? I shall attempt to answer for them, and in so doing to tell something about the plan and program of psychobiological research in which they figure as principals and to exhibit our objectives.

Yale is organizing a concerted attack on major problems of human behavior. The undertaking is as difficult as it is ambitious. For many lines of inquiry human subjects either may not be used because of incalculable risks of harm to the individual or may be used only with embarrassing limitations of action. It is here we discover use for the ape as instrument of progress. I beg to quote, with minor alterations and condensation, from a recently published statement.[1]

Why study anthropoid apes, or any other infrahuman primate, when there are so many idle and apparently next to useless human subjects at hand? Why, indeed! Chiefly because the anthropoid ape is the natural and desirable substitute for man in many types of investigation at this time and in our civilization on account of (1) superior availability and controllability, (2) close resemblance to man structurally, functionally, and presumably also experientially, and (3) consequent peculiar values of methodological, factual, inferential, and theroretical discoveries and formulations in anthropoid research.

So marked is the contrast in degree of availability and controllability of man and ape that the latter only may be even considered for use in varied studies in *genetics*—experiment by selective mating, cross breeding, artificial fertilization, etc.; *physiology*—studies involving operations on a living organism, and other radical changes in the physiological economy; *neuro*— and *psychopathology*—experimental control of neural development, production of atrophy and hypertrophy, inducement of mental defects and diseases; *psychology* and *psychobiology*—continuous, controlled observation of the origins, genetic relations, and values of major aspects of experience and response; for example, those generally classified as nutritional, reproductive, linguistic; *sociology*—experiments involving prolonged isolation of the individual, segregation and control of social groups, analytical study and measurement of the values of the social stimulus; *pedagogy* or *experimental education*—radical analyses of motivation; modes of adaptation; inhibition, reënforcement, or creation of behavioral patterns; suppression, intensification, or creation of interests; trial of new, and possibly dangerous, pedagogical procedures; and *hygiene*—in the hygiene of sex, for example, experimental studies of life history in isolation versus natural social environment; observation and control of sex impulse and its expressions; genetic study of sex and reproductive activities and experience throughout the life history of the individual.

Preliminary Architects' Sketch of Anthropoid Experiment Station in Florida.
(Courtesy of Messrs. Kimball and Husted, Architects).

Public opinion, investigative wisdom and insight dictate that the anthropoid ape be used, initially at least, in preference to

[1]Robert M. Yerkes, A program of anthropoid research, *Amer. Jour. Psychol.*, 1927, vol. 39, pp182, 183, 184.

man for many of the lines of inquiry enumerated in the preceding paragraph. In most instances it is a sheer matter of necessity, since human subjects cannot be used. But in any case, use of the anthropoid subject will cost far less in dollars, laborious hours, anxiety, risk of social censure and legal infringement.

What problems are being studied in the Yale Primate Laboratory and what is the nature of the program of research? At present there is concentration on certain groups of psychobiological problem which concern physical development in relation to nutrition and other environmental factors and to the development of behavior; parental, familial, and other social relations; reproductive behavior, development from infancy to maturity; emotional characteristics, expressions, and relations; the nature and conditions of temperamental traits, factors in individuality and personality; aspects of educability or behavioral adaptation, use of objects as implements in adaptation; language and intercommunication. Knowledge of any of these aspects of primate life may throw significant light on human problems and facilitate their solution.

The program of research on which we are engaged is not all-inclusive, but instead specialized for attack on psychobiological problems of vital human interest. Its distinctive feature is the substitution of ape for man as experimental subject. It assumes the concurrent study of physical constitution, behavior, and mind—groups of phenomena which are largely uncontrollable at present in individual and group and whose characteristics, conditions, and relations are incompletely known.

Certain requirements of work under this program cannot be satisfactorily met in the New Haven Primate Laboratory. Among them are the need for adequate knowledge of the natural life and environmental relations of our anthropoid subjects and detailed dependable knowledge of the ancestry and life history of individuals which are to be used in experiments. Indicated as means to the satisfaction of these related and mutually supplementary needs are the following three types of research establishment and varieties of inquiry: special laboratories in university center, field-camp laboratories, and subtropical breeding and observation station.

Already Yale has provided academic headquarters for our program of work and during the past five years in the New Haven Primate Laboratory varied investigations have been conducted satisfactorily. There are prospects that this laboratory will eventually become, or be merged with, a Department of Comparative Psychobiology in the University Human Welfare Center. Thus would be achieved preëminently valuable facilities and relations for the study of problems of individual and group behavior as exhibited by the anthropoid apes.

Field camps, either temporary or permanent, for systematic and sustained investigation of mode of life and relations to environment, can readily be established in the habitat of chimpanzee and gorilla (Africa) and of the orang-outan (Borneo and Sumatra). Already the way has been prepared for naturalistic study of the chimpanzee in Africa by preliminary reconnoissance made by the writer in French Guinea during the past summer; and arrangements have recently been perfected for Professor Henry W. Nissen, of the staff of the Primate Laboratory, to spend the greater part of the current academic year in French Guinea. His naturalistic observations will be conducted with the coöperation of the authorities of the African laboratories of the Pasteur Institute at Kindia and he will use that institution as base of operations.

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OUR CONTRIBUTORS

William Healy, who writes on Factors Influencing Individual Capacity in this issue, is the Research Associate of the Institute of Human Relations at Yale. He received his A.B. degree at Harvard in 1899 and his M.D. at the University of Chicago in 1900. He did post graduate work in Vienna, Berlin, and London up to 1907. Since then he has carried on intensive studies of criminals. He has written many books and articles on this and related subjects.

G. Proctor Cooper, whose article on the scientific discovery of rare trees appears in this issue, received his B.S. degree from the University of Minnesota in 1925. During the World War he served in the United States Navy and participated in the surrender of the German High Seas Fleet at Scapa Flow and Rothsea. In the fall of 1928 he was appointed Field Assistant of Tropical Forestry after which he went to Liberia as field secretary for the Department, making botanical and wood collections mostly on concessions of the Firestone Rubber Co.

Professor Lorande Loss Woodruff, whose article on the National Academy of Sciences appears in this issue, came to Yale University in 1907. Be became a Professor of Biology in 1915 and in 1922 he became Professor of Protozoology. He is an Associate Editor of the Journal of Morphology, a trustee of the Marine Biological Laboratory at Woods Hole, Mass., and in 1928 he was the chairman of the Biological Division of the Natural Research Council which met in Washington. During the war he served as a Consulting Physiologist in the Chemical Warfare Service of the United States Army.

Assistant Professor Stanley McCandless, who writes on Stage Lighting and Illumination, received his A.B. degree from the University of Wisconsin. From there he went to the Harvard Architectural School, receiving his M. Arch. in 1923. At Harvard his interest in Drama was greatly stimulated by work under Professor Baker in his 47 Workshop. In 1923 he held the Sheldon Fellowship from Harvard for architectural studies abroad. For a time he was Technical Director of the Neiborhood Play House in New York City. In 1925, when the Yale Theatre was organized, he came here as Instructor in Stage Lighting under Professor Baker. He designed the switchboard at the Yale Theatre, which has become nationally known as the "Yale Type".

Dr. Raymond Hussey, who writes on Pathology in the Yale Medical School, was graduated from the University of Maryland in 1911. In 1913 he joined the staff of the Johns Hopkins Hospital. During the war he was an Adjutant in the A. E. F., supervising the laboratory work of bacteriology and pathology. Then for two years he was Assistant Professor of Pathology in the Cornell Medical School. He came to Yale in 1924 as an assistant professor. In 1927 he was promoted to the rank of professor and made head of the Pathology Department.

Professor S. W. Dudley, whose article on New Developments of Automatic Train Control, appears in this issue received his Ph.B. in the class of 1900 S., after which he taught Mechanical Engineering for three years. In 1905 he joined The Westinghouse Air Brake Co. and soon after was made local engineer in charge of the installation of the electric locomotives and multiple unit cars for the New York Central and the New Haven Railroads. He is an authority on the application of braking mechanism. In 1921 he became Professor of Mechanical Engineering and two years later was made head of the department.

(Continued on page 35)

Pathology at the Yale Medical School

The Facilities of the Yale School of Medicine Include Extensive Equipment for the Study and Practice of the Various Phases of Pathology.

By Raymond Hussey

Of all the subjects included in the University curriculum that pertain to medicine there is none less frequently understood by the layman than pathology. If one happens to be curious enough about it to seek information in the dictionary or encyclopedia he will complete the task without great reward. As a matter of fact, it is quite difficult to give a satisfactory definition for any of the various subjects generally included under medicine since each one is concerned in some way with contributing to a better understanding of disease and diseases. The object of this article is neither to attempt to define pathology, nor to enter upon a discourse concerning what one should understand about pathology, but rather to present some information about the activities of the division representing this subject at Yale.

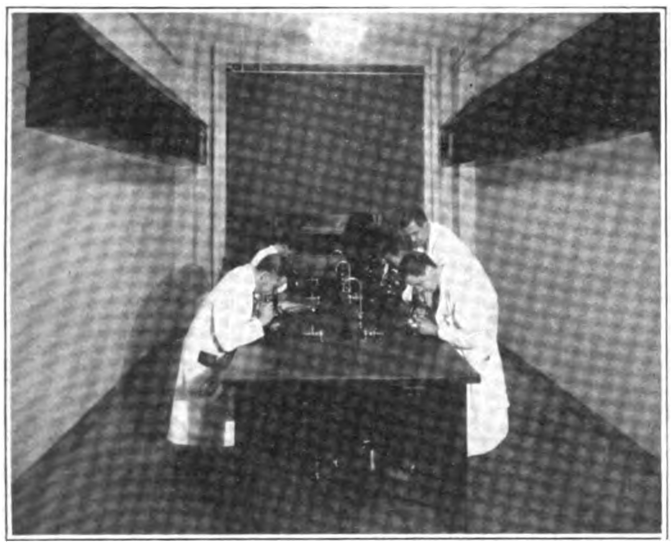

Fig. 1. Student Class Room.

Among the first contributions made to what is generally called modern medicine was the examination of the body after death with the idea of ascertaining what changes, if any, existed in the tissues and how such changes might be correlated with the symptoms and physical signs of disease during life. This phase of pathology is known as anatomical pathology and the term necropsy is employed to indicate the procedure followed in making a postmortem examination. In the Anthony N. Brady Memorial Laboratory where the Division of Pathology is located there are two rooms on the first floor for this work. The marble operating tables are movable and especially designed to furnish every possible working convenience. In the floor just beneath the tables there are receptacles containing outlets for hot and cold water, gas and electricity, and drainage. These outlets are fitted with easily detachable tubes to connect with corresponding fixtures on the tables. Adjacent to one of these rooms there are combination locker and wash rooms, one for students who are assigned to necropsy work, and the other for members of the staff.

Next to the other necropsy room one finds a room provided with an injection apparatus employed in the preparation of tissues for study. On the floor below and immediately beneath this suite there is an embalming room and museum preparation room. In the performance of a necropsy the body of the individual is in charge of a licensed embalmer and the whole procedure is carried out in as private a manner as is possible. Every change observed in the body is carefully noted and recorded on a dictaphone, which is later transcribed for permanent record.

After the completion of the necropsy the clinical history and anatomical data are gone over in conjunction with the physician who attended the case. Subsequently the anatomical findings together with the clinical history are discussed with the staff and then with the students so that any lesson to be learned from the experience is brought to the attention of all persons interested. Also each week during the school year a conference is held to which all physicians are welcomed. Last year 230 necropsies were performed in these rooms and the staff was called upon 40 times to go to other hospitals or private homes to perform necropsies.

Fig. 2. The Art Studio.

The outside service rendered by the staff is one of the most important of recent developments in the work of the division and the fact that each year there is an increase in the number of calls indicates the interest being taken by physicians. The necropsy represents a really vital link in medical education and every effort is spent to inform the public of this fact. Yet it is with great difficulty that permission is secured from relatives

to allow this examination. In Europe, the attitude of the public is entirely different and necropsies are performed on at least 95% of individuals who die, in contrast to 50% or 60% in this country.

In the basement, there is a suite of four rooms in which the tissues removed at surgical operation are studied. This activity is usually spoken of as surgical pathology. When an operation is performed the diseased tissue is sent to the laboratory where a careful examination is made and the data is recorded. Preparations are made for microscopic study and these findings are subsequently reported at a staff meeting. Here again the activities go beyond the walls of the New Haven Hospital. Indeed, any hospital throughout the state of Connecticut has the privilege of sending specimens to the laboratory for diagnosis for a charge that covers the actual cost of handling the material. This service makes it possible for smaller hospitals to have laboratory advantages otherwise impossible.

It might be said that the activities outlined above represent the routine of the division and while no effort is spared in promoting this feature it is certainly true that real progress in pathology depends upon the success attained in experimental investigation. At Yale much emphasis is laid on this and each member of the staff is interested in some "arbeit" which he carries on in conjunction with his routine duties. There is an animal operating room available which is equipped with every facility for general anaesthesia administration and aseptic operative technique. In another part of the building a room is put aside to serve as a hospital ward for animals that have been operated upon.

Bio-Physical Research.

On the second floor there are two suites of rooms, one of the rooms is equipped for chemical technique, another for techniques

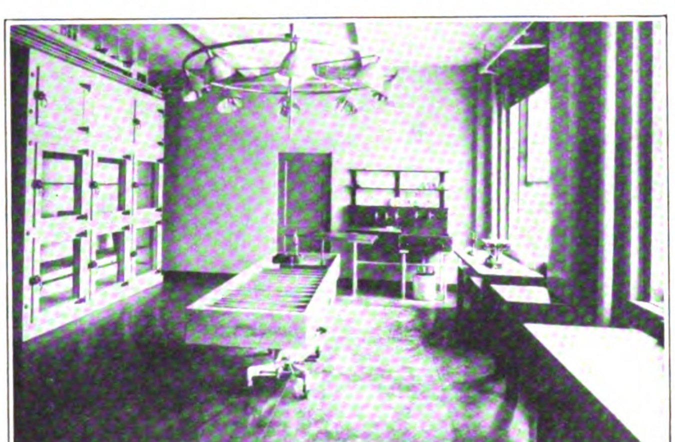

Fig. 3. One of the Autopsy Rooms.

employed in biophysical investigations. One of the chief features of the laboratory for biophysical research is an X-ray plant which has a transformer capable of generating 230 kilovolts and 60 milliamperes of current; and a water cooled tube which may be operated at 200 kilovolts and 50 milliamperes of current. This plant is used exclusively for biological investigation. Other facilities are available for work involving viscosimetric measurements, and projectometric work. The developments in projectometry have been concerned with studying geometric configurations represented by various anatomical structures, e.g. the islet tissue of the pancreas. Through this technique it is possible to ascertain the volume of insular tissue as well as the number of islands present in the pancreas. Having established this method it has been possible to proceed with an experimental investigation of the relation of change in insular tissue to altered carbohydrate metabolism. The result of this investigation may lead to valuable information concerning a controversial issue

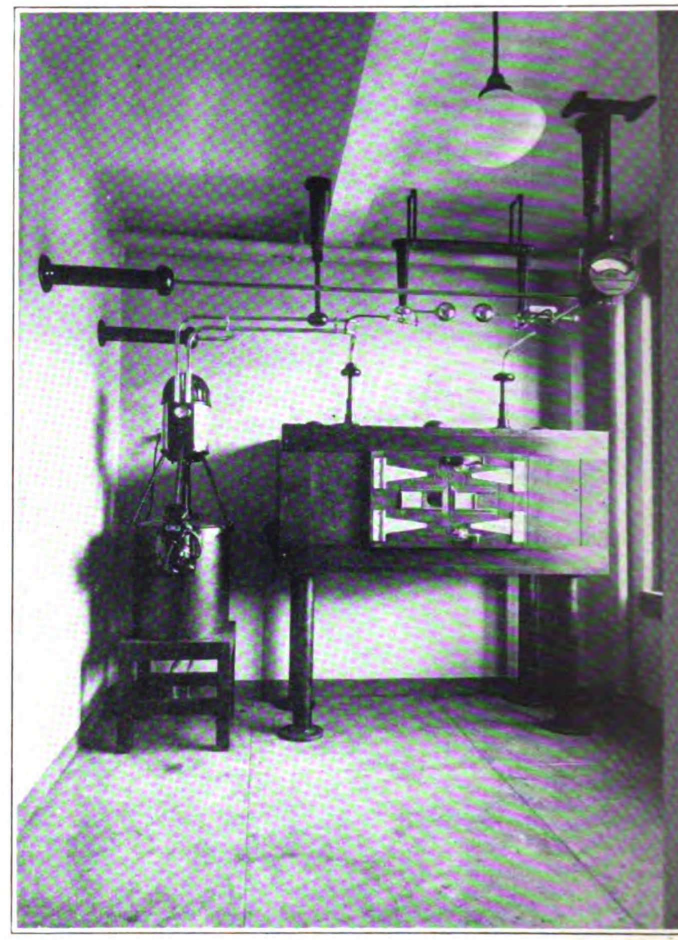

Fig. 4. X-Ray Tube Box with Water-Cooling Apparatus.

about insular change in diabetes. Until a few years ago there were no simple methods available which permitted the study of protein splitting enzymes—trypsin and pepsin. Now by observing the change in the time of outflow through viscosimeters of a gelatin preparation mixed with either of these enzymes we have a precise means of determining the enzyme activity. This method has permitted the investigation of the influences of radiations from radium emanation, X-rays and ultra-violet radiations on enzymes and the experimental data established has cleared a subject which was quite muddled for several years. Recently there has been perfected a similar procedure with the use of starch solution for the study of amylytic enzyme activity. With this method it has been possible to study the amylytic properties of the blood, a knowledge of which aids considerably in the diagnosis of disease and in following the clinical course of the patient. Space and equipment are also available for investigations involving statistical analysis. A great deal has been accomplished through the methods of statistics in the study of the association between changes in various organs in diseased states. In another room, facilities are available for raising and maintaining insects which are employed as experimental material. The larvae of insects have been used to study the influence of X-rays on certain

(Continued on page 40)

The Problem of Lighting and Illumination

With the Aid of the Illuminating Engineer and Designer, Lighting is Gradually Assuming an Artistic Quality.

By S. R. McCandless
Assistant Professor of Lighting, Yale University Theatre

THE control or production of light bears the same relation to its design as does the steel structure of one of our monumental buildings to the architectural lines that establish its form. Lighting must not only serve as a means of seeing, it must also be designed so that the final result is satisfactory both technically and aesthetically. It presents a dual problem.

Structural steel has created a new architecture without precedent, but the designer is just beginning to realize the opportunity that has been placed in his hands. The slavish adherence to Renaissance or Gothic styles which were based fundamentally upon stone and mortar construction is slowly passing, and we see on our new buildings only ornamental features that suggest the past. The basic laws of steel construction have long been known by the engineer, but only now is the architect beginning to realize that if he applies those laws, he can erect buildings which are as functional and beautiful as the monuments of the old world. But first he must understand the laws that govern the use of steel.

The same story is true of lighting. The candle, oil lamp, and gas jet still set the style for electric fixtures. Yet the electrical engineer is in a position to supply economically practically any amount of candle power which need not be projected from visible, imitation fixtures. He has developed a control which can vary the intensity, the color, or the distribution, or all three together, and this control is only awaiting proper application to the use of light. Of course, all of us cling to the idea that the old method was adequate and we are not sure of the value of the new, so we continue to demand replicas of the past even though the necessity that brought them into being is dead. We are not ready to accept the soaring, clean-cut lines established by the steel form of the building, so we literally suspend heavy Renaissance and Gothic ornament from the steel skeleton just to remind our neighbor that we have not forgotten entirely the canons of the past. We put imitation candle sconces on the walls of our living rooms, and then proceed to hide them with shades because the effect is more comfortable. The scientist and the engineer are well ahead of the designer because they do not have the variable, incalculable nature of the consumer to deal with directly.

Both the designer and the engineer are working toward the same goal. Whatever they produce is prompted by the demands of the mass of individuals. But the constant difference between the methods of approach and the lack of co-operation between these two men form the chief problem. The designer, in trying to interpret the desires of the individual, discovers that very few hard and fast rules can be applied. The engineer rebels at the lack of precision and the innumerable variables that enter into direct contact with the individual. There are only too many examples of the unsatisfactory attempts of each one working separately. The difference between the contractor-built house and that designed by a reputable architect is an obvious case in point. Often the use of light, as we see it today when laid out by the engineer alone, bears the same analogy.

Our ignorance of the possibilities of lighting is, as a rule, shared by the designer. He either avoids considering it, or makes inarticulate gestures which may be sound in conception from an artistic point of view, but which have no suggestion of how they may be produced. The designer must be able to bring his dreams down to concrete expressions. He cannot expect co-operation from the engineer in solving the problem until he is able to meet the producer half way, and he will never be able to do this until he knows as much about the qualities of light as the architect knows about steel construction.

The Illuminating Engineer

In the development of the mechanics of electricity for the production of artificial light, it is natural that the technical should precede the aesthetic. The practical problem of creating current and a means of control has gone ahead in numerous other electrical fields so that it is only a problem of assembling the parts and putting the machine to new uses. But light is a product which is consumed directly by the individual; therefore, his likes and dislikes, both obvious and unconscious, have to be considered. The illuminating engineer has come into being to solve the technical problems involved, and he has made great advances in the use of artificial light. It is beginning to be clear, however, that a designer is necessary to bring the real wants of the consumer to the attention of the engineer. He must take the place of the architect between the client and the structural engineer, and he must co-operate completely with both.

Since we must assume that the public is somewhat inarticulate about its most crying needs, it devolves upon the artist to interpret those needs from one generation to another. The artist depends upon the technician to produce the materials which carry out his design. Illuminating engineering is a growing mass of information calculated to supply this need, but the average designer finds the material too technical to interest him. The elaborate exhibitions which have been prepared by the lamp companies and various equipment firms, up to the present, seem to exist only as museums and interesting displays. The layman seems at a loss to interpret these displays in terms of his own existence without the assistance of the designer—the lighting architect—to work out his particular problem, as the architect does for his client in the case of a house or a building.

The co-operation between the client, designer or lighting expert, and the illuminating engineer is an obvious necessity. The lighting expert must interpret the needs of the client, then design the use of light with precision from an artistic point of view to give the most satisfactory result, and present his plans as the architect does to the engineer. The engineer must follow the spirit of these plans in carrying out the technical features of the design. It is quite impossible to hope that any one of the three mentioned should know all the details of the other's job, especially in such

a new field as lighting, so that co-operation must be the keynote of development.

The illuminating engineer has had to assume the rather nebulous duties of the lighting designer up to the present time. By his very nature, the engineer desires to reduce all things to formulas; but where the human being is concerned, formulas serve only as a starting point. The only criticism of the illuminating engineer is that the necessary working principles which he has developed have become too early crystallized to apply to all the advanced uses of light. The obvious fact that we must have sufficient light by which to see has led him to believe that, for the most part, a certain number of foot-candles on the working plane would solve all problems. It was indicated by Steinmetz, and later by Luckiesh, that this is not the whole problem. Most illuminating engineers and the central research laboratories have admitted the same fact, but the right direction for development does not yet seem clear.

Research along the lines of the psychological effect of light on the individual has been carried on to a great extent in some of the lighting laboratories, but the experiments and findings have been applied to the more technical problem of lamps and fixtures. Psychological tests have much more bearing on the problem and, to a certain extent, the lighting laboratories have made use of the findings, but even here the statement of the problem is so confused that the engineer does not apply the principle, nor has he often found it advisable to do so.

The Problem of Illumination

The problem seems to separate itself into three phases: the production of light in all its qualities such as we have become accustomed to in the natural surroundings of daylight; the physiological reaction of the individual due to the construction of the eye; and the psychological effects of the previous steps under differing conditions. The first two are obvious problems which have already had some attention in the matter of creating artificial lighting, but we are only able to grope toward a solution in the last—the psychological effect. The word of one man is almost as good as that of another under present conditions. We all believe that lighting can create decided and diversified emotional reactions in the individual. The motion picture with its twenty-odd million weekly attendance is sufficient evidence of the appeal of one use of light. To be sure, the associational value of the moving patterns of light in the motion picture depends more upon the objects photographed than upon light itself, and is only an indirect example of what we might call the art of lighting, yet it demonstrates two definite qualities of light —form and movement—and shows that we have hardly begun to touch the possibilities that are at hand.

The atmosphere of any room where artificial or natural light is used as a means of seeing and feeling things is dependent, to a great extent, upon the presence of light rays of a certain intensity, color, form, and movement. The changing qualities of light can alter any fixed condition of seeing and indirectly affect the emotions of the individual. If it is not to be denied that light can influence our feelings in regard to a certain place, in other words, that as designers we can control the individual mood to some degree by means of light, it is worth while knowing how this can be done. It involves the understanding of how light affects the individual and then providing the means for producing that light. The designer's job is the former, and he depends upon the engineer to supply the latter. Both must co-operate because the designer has today very little to guide him, and the engineer has been so interested in practical demands that he has not kept pace in supplying the special means of control for the lighting that the designer now knows he must have.

Lighting and the Theatre

Perhaps you have lingered in the theatre after a performance, and seen the curtain rise on an empty stage where only a few moments before a most entrancing scene had swayed the audience with its dramatic beauty. There was a single bare lamp mounted on a tripod stand casting spooky shadows over shabby canvas-covered wooden frames stacked against the dirty brick wall where seemingly there had been limitless sky before. Coatless stage hands were performing their illusionless duties, and ushers were raising the seats in the darkened auditorium. The materials were all there, but the illusion was gone. Sham though it is, and we know it, the theatre affords a striking example of the impelling, illusion-giving power of lighting.

Stage lighting is admittedly a special use of light which electricity has raised to a high level of possibility, but the tools which make it possible and the advantages given it in construction and equipment, although far more flexible than those used ordinarily in lighting, are still relatively crude when compared with the desired results which we know will move the individual. In the final analysis, all lighting is designed to satisfy the individual and to appeal to him for some specific purpose. It is true that the canvas walls of the stage setting are not suitable for the intimacy and solidity of our homes, but the atmospheres that create certain moods of geniality, restfulness, or festivity are or may be as much a desirability there as in the theatre. One definite way of obtaining these is by means of controllable lighting.

Good stage lighting attempts to move the audience unconsciously. There should be none of the "take it or leave it" attitude about its inception, although the average effect seems to have had that genesis. The convention is too obvious and the sham too apparent for there to be any art or science connected with it. Only when the lighting by means of its perfection becomes literally unnoticeable (and, therefore, apt to receive less credit), does it seem respectable enough to be called an art.

All art must have a certain amount of technical preparation in order to be applied by the artist. The demand for pure paints has called into service all the knowledge and resources of great chemists. Scientists and engineers are constantly striving to supply architects with new methods and materials. So with lighting, we can expect an improvement only when the engineer turns his mind to the production of more flexible equipment for the control of light. This will come only when he senses the demand, and considers it "respectable" enough to deserve his attention. When the designer is able to prove that there is an art to lighting, a fact which the illuminating engineer has long been sure of, but has been unable to prove thoroughly because of his insistence upon formulas and a disregard of artistic principles, the public will demand a more extensive use of light. What now appears to be a luxury will be the necessity of tomorrow. It seems strange that the more human use of light has not been developed heretofore in this scientific age. Perhaps too few people know what can be done to make life more comfortable and beautiful by means of light. I am inclined to believe that the true interpretation of the problem waits on the artist, and that every mechanical aid should be given him

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Tendencies in Marine Engineering Design

The Present Situation in Marine Engineering and Design—Some Probable Developments in this Field.

By Professor H. L. Seward

THE attention of our modern marine engineers is now concentrated on the problem of evolving the most reliable form of power plant which will convert fuel energy into propulsive effort plus the other necessary services at the least overall cost consistent with the special conditions imposed in any given case. If the statement of the problem includes a curve of horsepowers at all knots and revolutions, limiting weights, expected auxiliary loads, cruising radius, type of service, available operating personnel, capital limitations and other information with its limiting characteristics, an opportunity is then offered for a study of the various possible types of equipment and arrangements to meet the conditions imposed. Further refinement in design based upon experience in like situations or upon development work and experience with the equipment under definite conditions then becomes possible. The designer must know all of the elements of which a total or unit cost is composed; he must work for economy but not at the expense of reliability or safety; he must come within certain limitations of space and weight but not at the expense of accessibility or facility of control, inspection, repair or adjustment. He must realize the limitations he is imposing on the operating personnel as well as the flexibility of the design to meet unusual or special conditions.

Much use has been made of the empirical method of design wherein certain established arrangements, such as Scotch boilers, reciprocating engines, steam driven auxiliaries, held permanent position in the field and variations occurred only because of the application of certain "variable constants" in the established formulas. Many of these relations were based on fundamental mathematical laws but their application became possible only when someone applied a coefficient which was largely experimental and included a wide margin of safety. A reluctance on the part of the marine engineer to give up practices which have proved to be good for those claimed to be better is but natural, although the comparison between advances made in power plants ashore and power plants afloat makes it appear that considerable inertia has to be overcome in the marine fraternity today. Equipment which has performed satisfactorily ashore cannot always be sent to sea because of the peculiarity of conditions under which it must operate there. Questions of corrosion, temperature, ventilation, the fact that foundations may be tilted in every direction at steep angles, as well as the complete isolation of the plant at sea from immediate possible help and the resourcefulness of the personnel in emergencies, all tend to introduce a note of caution in the designer's mind which has made marine engineering practice appear to lag far behind stationary practice. One modern authority has said that there are now building in various shipyards throughout the World, seagoing ships whose machinery would have been no particular credit to a designer of thirty years ago.

It is now apparent that a change is taking place in the attitude of marine engineers and designers towards the use of the fundamental sciences as well as in the application of more modern apparatus in marine power plants. Such items as heat balances, cost per ton mile, quick turn around, CO_2 percentages, port efficiency and the like are now being discussed. An application of the more analytical type of study is being made to the records of operation and an explanation is being sought for all discrepancies, variations or differences which are noticed when comparisons to established standards are made. At the last meeting of the Society of Naval Architects and Marine Engineers in New York it was pointed out that the topics discussed in the papers presented before the society included an interesting range of engineering subjects, many of which would not have been considered possible on the agenda of ten years ago. Some of these subjects were pulverized coal, air preheaters, stokers, Diesel engines, electric auxiliaries, turboelectric drive and the use of welding.

In the present paper there can be included mention of only a few of the outstanding developments with an attempt to point out significant tendencies. Descriptions of new marine power plants have been well published in current literature. Reports of accomplishments in performance and economy have not been so regularly made in the press except for commercial advertising purposes. It is obviously more difficult to secure reliable operating data from a plant which includes some radically new designs because of a natural desire of the owners to wait until conditions have steadied themselves, adjustments have been made and operating personnel have become accustomed to its characteristics, before publishing the data, even before technical societies.

Boiler practice is making substantial use of central station experience, although the space and weight limitations are obvious. Many years ago there was a feeling amongst marine operating engineers that the boiler room was a necessary evil and a place to keep away from, but today there is a realization that economy is made or lost in the control of combustion and in the care and attention given to apparatus in this department. Present designs are well illustrated in such plants as the S. S. *Dixie* and the S. S. *Virginia*. Proposals and designs of current work are apparently based on the experience gained with these ships which represent a moderate rise in steam pressure. Some designs are being laid down with air heaters, superheaters and a pressure of 375 pounds. The question of higher steam pressures is directly related to the size of the power plant. If the plant is of low horsepower, it is obviously inadvisable to go to such a high steam pressure as to reduce the size of the turbine blades to a point where they become so small as to be inefficient. In the higher powered plants the boiler designer and the turbine designer must get together in order to work out the most reasonable steam pressure and the necessary supplementary conditions. It is hoped that among those who are considering installations of around 70,000 hp. or more there will be someone with courage enough to go to 1200 pounds initial pressure. The initial cost

should not be much different from present costs, judging by shore experience in building high pressure boilers.

The application of equipment to pulverize coal and burn it in Scotch boilers on the S. S. *Mercer* is well known. This is one activity of the Fuel Conservation Committee of the United States Shipping Board, whose outstanding contributions to marine development have been well known since its organization in 1922. From a paper by Messrs. Jefferson, Evans and Broshek entitled "Development of Pulverized Fuel for Marine Purposes, 1927-1928" before the Society of Naval Architects and Marine Engineers in November 1928, the following quotations are taken. The authors are pioneers in this field.

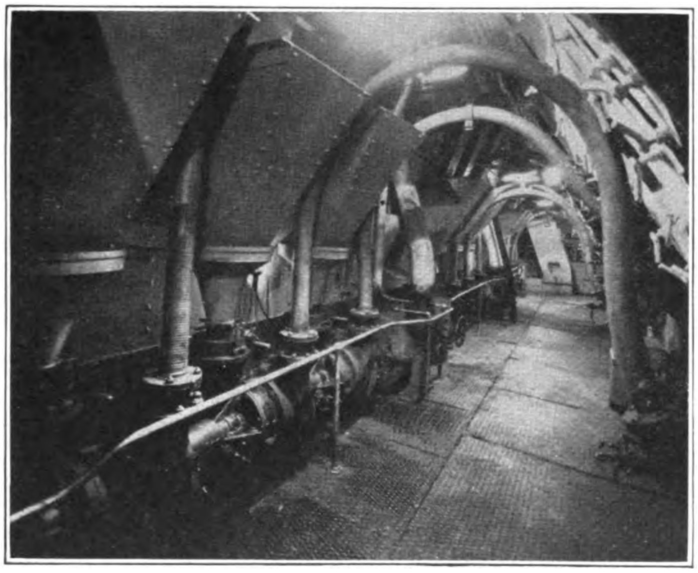


Fig. 1. Installation of the Todd Unit System of Pulverized coal burning equipment on the U. S. Shipping Board S. S. West Alsek.

"The year's operating service of the S. S. MERCER has brought out several salient points that must be observed in effecting a satisfactory installation of pulverized fuel in Scotch marine boilers, which may be summarized as follows:

(a) Considerably finer pulverization of fuel is required than that necessary with large refractory lined furnaces such as found in shore plants.

(b) High turbulence of flame is required to produce complete and rapid combustion necessary in the comparatively short flame travel characteristic of a Scotch boiler.

(c) Consistently uniform distribution of pulverized fuel between various furnaces of Scotch boiler is necessary to maintain efficient performance.

(d) The power plant incident to producing pulverized fuel must be of an economical type, which may be secured either by installation of efficient low water rate units, or by useful employment of exhaust if less efficient units be used.

(e) Extra precaution must be taken to secure dust-tight smoke box doors and uptakes; otherwise, when using soot blowers it will be impossible to maintain a satisfactory fireroom condition.

(f) The velocities of coal stream throughout cycle requires special consideration to prevent overloading of fans and coal precipitation in pipe lines and to secure satisfactory selection of superfine grind from mill and turbulence at burner.

(g) Personnel must be trained to give the same close supervision to "velocity" as is required in regard to viscosity and pressures when using fuel oil.

(h) The usual fireroom instruments, such as orsat and pyrometer, are important but of greater importance are the draft gauge and smoke indicators.

(i) Sized coal, or 100 per cent slack coal, gives more uniform operating conditions than will run-of-mine, in fact, bunkering with run-of-mine will require use of crushers to produce fuel having a limited maximum size, otherwise, feed to mill will be very irregular, a condition that will be reflected throughout the whole operation of boiler plant."

Several other applications of pulverized coal to seagoing plants have been made and its reliability and safety are well established. The ability to use satisfactory fuels which could not be used otherwise in a Scotch marine boiler has likewise been definitely demonstrated. One of the most difficult problems in firing a three furnace boiler with pulverized coal has been that of evenly dividing the air-coal stream; i.e., proper distribution. Many types of pulverizers have been tried and have failed but better progress is now being made. The solution to the problem as offered by the Todd Dry Dock and Engineering Corporation consists in providing individual mills for each furnace of the two-stage impact type (3600 r.p.m., motor driven). As each mill requires about 10 hp. the auxiliary electrical load is rather high and development work is now being done on a plan to drive the three mills of each boiler by a steam turbine through clutches.

Mechanical reduction gears were given their first real opportunity for service afloat in 1910 and have made a very satisfactory reputation for themselves. Few other mechanical devices have been built with efficiency curves sustained so flatly at such high levels. When properly built and cared for, a set of reduction gears will go several hundreds of thousands of miles. They have been installed in almost every type and size of naval and merchant vessel in both the United States and foreign countries. There are many types and sizes of ships where the geared turbine form of drive is the logical installation because it has the lowest first cost, good economy, reasonably low weight, does not occupy excessive space, is simple and reliable and has a low maintenance cost. Much effort has been spent in investigating tooth curves, lubrication, flexible forms of pinion support or gear design so that at the present time a turbine and gear built by one of the recognized manufacturers can be installed with the assurance that it will operate successfully. There is so much latitude possible in the relative arrangements of centerlines that the geared turbine has been applied to single or twin screw plants, single, double, triple or quadruple pinions per gear, and in jobs where a particular arrangement of turbine and condenser is desired. In the S. S. *Malolo* there are two gears on each of the twin screw shafts, two turbine pinions on each gear, eight turbines in all. Marine geared sets have been built up as high as 32800 s.h.p. per gear with 1000 lb. tooth pressure per inch of face at 3000 r.p.m., which corresponds to 105 lb. per inch face per inch of pinion pitch circle diameter.

When the United States Navy brought out the three colliers *Cyclops*, *Neptune* and *Jupiter*, it was the Neptune which proved the case for mechanical reduction gears (in addition to work done by Parsons in England) but the Jupiter (now Langley) proved the feasibility of the turboelectric drive. A real step forward was taken when the decision was reached to apply the system to the six battleships *New Mexico, California, Tennessee, Maryland, Colorado,* and *West Virginia,* with approximately 35000 s.h.p. Their maneuverability and flexibility in operation are truly remarkable. The experience gained by American manufacturers in connection with the 180,000 s.h.p. power plants of the U. S. Airplane Carriers *Lexington* and *Saratoga* has been especially valuable and it is hoped that the possibility of applying this experience to passenger vessels demanding horsepowers on the order of 100,000 s.h.p. will soon be an accomplished fact. The S. S. *Virginia* of the Panama Pacific Line on her first trip from New York to San Francisco had an average fuel consumption of 0.74 lb. oil per s.h.p.-hr. for all purposes including a very heavy refrigerator load. Considering that a large part of the voyage was made through sea water at 78° to 84° fahr., and that this was her first trip, make this record worthy of praise. The smoothness of operation and the absence of vibration have been frequently made the subject of comment by passengers.

The following table has been prepared by Mr. Frank V. Smith, Marine Department, General Electric Company. Particular attention is called to the last line.

For a plant such as might be used in a liner of approximately 50,000 tons displacement with a maximum speed of 26 knots but with a normal sea speed of 23.5 knots with an average of 56,000 s.h.p., the following analysis is applicable:

MAIN MACHINERY:
Four turbogenerators, 15,200 KW each.
Four synchronous induction double motors, 10,000 S.H.P. each, 240 r.p.m.
Four auxiliary D.C. generators, 1000 KW each, 230 Volts.

STEAM CONDITIONS:		
S.H.P.	*55,000*	*80,000*
Pressure, lb. per sq. in. at turbine throttle	275	275
Superheat, Deg. F at turbine throttle	200	200
Vacuum, In. Hg. referred to 30" Barometer	29.0	29.0
W/H-Lb. steam per propeller SHP/Hr.	8.2	7.75
STEAM CONSUMPTION:	*Lb. Hr.*	*Lb. Hr.*
Main turbines without extraction	451000	620000
Admit in lieu of steam extraction	22500	40000
Total steam to main turbine throttle	473500	660000
Auxiliary Turbine D-C Generator sets	26400	37200
Steam Auxiliaries	20250	25230
Steam used for other purposes	17930	19090
TOTAL Steam Consumption	538080	741520
LBS. STEAM per SHP/Hr. for all purposes	9.78	9.27
FUEL CONSUMPTION:		
Lb. steam evaporated per lb. fuel burned, based on a boiler efficiency of 82 per cent; fuel oil having a heat value of 18500 BTU per lb.; and a feedwater temperature of 230° F.	13.5	13.5
Lb. Fuel Oil per hour	39900	54900
Tons of Fuel Oil per Day	427	588
Lb. Fuel Oil per SHP/Hr. all purposes	.725	.687

A Dieselization Fund of $25,000,000 has been set aside by the Congress of the United States for the purpose of developing, in the government merchant marine vessels, the art of applying Diesel engines. Dieselization has been applied to three series of ships, one series now being in full commercial operation. Full reports of the program as well as such operating data as are available have been thoroughly presented at meetings of the Society of Naval Architects and Marine Engineers by Capt. R. D. Gatewood, and reference is made to those reports for detailed information. The first series of installations were in twelve single screw cargo ships of about 3000 s.h.p. each. Four different builders provided the engines, of which two-thirds are two-cycle, one-third are four-cycle; some are double-acting, others are single-acting, four cylinder or six cylinder, but all are direct connected. Some have independent auxiliaries while others have direct driven air compressors and pumps. Engine builders in the United States have gained valuable experience in building these engines. The initial costs have been excessive. Although mechanical difficulties have been experienced, they are such as would normally be expected in an extensive program of this nature, which is purely pioneering, and to a certain extent experimental.

The Diesel had a decided advantage over the steam-driven cargo ship in port performance but is at a great disadvantage in the use of lubricating oil, which has cost about 6 cents per mile. It is but natural that no chances would be taken by the operating personnel in the use of lubricating oil on these new installations. Some of the series of eight more ships to be fitted out with direct drive and three ships with Diesel electric drive will perhaps be in operation by the time this paper is read. Space does not permit a discussion of the Diesel engine in yachts, electric ferry boats and tugs nor of its fine history in submarines. Some developments looking towards a simpler and less expensive form of Diesel engine in the smaller sizes appear to have some promise of success.

The United States Coast Guard Service, through its Chief Engineer, Commander Q. B. Newman, is making some very important contributions in the art of marine engineering and design. The ships of this service are small cruising gunboats about 250 ft. long, making 17 knots with 5000 s.h.p. The storms which keep other vessels in port are often the cause of the Coast Guard Cutters putting to sea in answer to calls of distress. They go looking for the icebergs which other ships hope to avoid because of the information faithfully furnished by the cutters. In the forgotten seas of the North these vessels are the whole United States Government. They must always keep to the sea—and keep within limited appropriations not inflated by war enthusiasm.

In 1920 the first turboelectric installations in the Coast Guard were made by the General Electric Company on the cutters *Tampa, Haida, Mojave* and *Modoc*. These ships were the first for which a synchronous motor was adopted to drive the propeller. While their machinery was in process of development it was proposed by Commander Newman that some of the auxiliary machinery be driven by current from the main generator. It is of interest to note that the contractors for the machinery refused to develop this idea for two reasons, which at the time were valid; turboelectric propulsion in as low power as 2600 s.h.p.

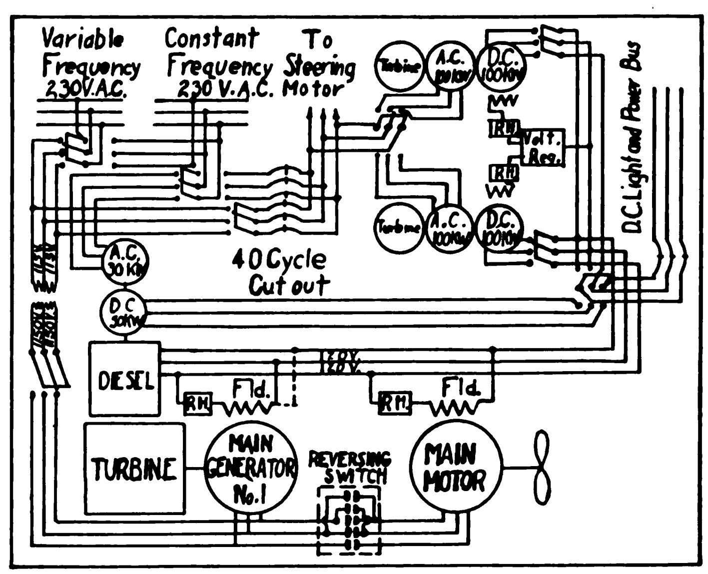


Fig. 2. A Schematic diagram of the main and auxiliary power of the U. S. C. G. cutter Ponchartrain.

had never been used and the synchronous motor was being employed for propulsion for the first time. It was considered inadvisable to allow unrelated problems to influence the success or failure of the new style of main machinery.

All of the auxiliary machinery for the four cutters was therefore of conventional steam driven types, known to be extravagant, but not even suspected of being bad enough to have a marked effect on the whole plant. And so when the four ships of the *Tampa* class failed to live up to expectations as to fuel

consumption, it was decided to conduct thorough performance trials of all machinery separately and then of the plant as a whole.

The *Modoc* was selected for the tests and the trials were run in August 1925. The results were astounding. At full power 32 per cent of all the steam produced was being used by auxiliary machinery, and more at lower powers. In fairness to the auxiliaries it should be stated that they were exhausting against eight pounds back pressure, and that some of the heat in the exhaust steam was recovered in the feedwater heater and in the low pressure stages of the main turbine. The results of the *Modoc* trials were presented as a paper before the Society of Naval Architects and Marine Engineers in November 1923.

An appropriation in 1926 made possible the signing of contracts in 1927 with the Westinghouse Electric and Manufacturing Company for the machinery of the five newest Coast Guard Cutters, *Chelan, Pontchartrain, Tahoe, Mendota* and *Champlain.* These vessels resembled as much as possible the central power house idea afloat in that they are electric-drive with as much of the auxiliary power as is at present possible being derived from the main turbogenerator. In accomplishing this, the chief difficulty to be overcome was in the varying frequency of the main generator, which corresponds to the speed of the ship. The fluctuation in speed of an alternating current motor while driving some auxiliaries, such as the main circulator, or fuel oil pump, may be desirable as its speed fluctuates with the speed of the ship, and may not be objectionable within certain limits for blowers, fans and a few other auxiliaries. It would be entirely unsuitable for lighting, radio, high pressure centrifugal pumps and refrigeration.

Since there is an absolute need of direct current for excitation, searchlights, battery charging and other D.C. power requirements there must needs be installed a motor generator set. The A.C. end of this set may be either motor or generator, depending on conditions, but the D.C. end must give a constant voltage.

The propelling machinery of these five Coast Guard Cutters consists of the main turbogenerator, 2500 kilowatts at 3600 r.p.m.; the synchronous propelling motor which develops 3000 shaft horsepower at 163½ r.p.m.; and the necessary control panel which contains the maneuvering switches and speed control. The auxiliary circuit is tapped off from the high voltage terminal of the main generator and is led directly to a power transformer which reduces the voltage to 230. The circuit is led from the low voltage terminal of the transformer to a disconnecting switch and a circuit breaker on the auxiliary switchboard, and from the circuit breaker to the a.c. motor of one of the generator sets previously referred to. A diagram of the electrical connection is shown in Fig. (1). An auxiliary steam turbine is connected through a speed reduction gear to the motor generator set and furnishes power to the generator at all times when the circuit between the main and auxiliary systems is open.

The auxiliary turbo-motor generator can be connected to the main generator at any frequency between 40 cycles and 60 cycles. It is, of course, necessary that the two machines be synchronized and in phase at the instant of closing the connecting switch, and a simple means is provided on the synchronizing panel for varying the speed of the auxiliary turbine to suit main generator frequency.

It would, of course, have been entirely practicable to use d.c. motors for all auxiliary machinery, but this would have necessitated a 200 kw. generator and motor, and the a.c. motor would have been idle at all times when the auxiliary turbine was furnishing power. By making 100 kw. of the auxiliary machinery a.c., and 100 kw. of excitation and auxiliary machinery d.c., the sizes of the motor and generator were reduced to 100 kw. each.

The voltage regulator is the all-important detail of the installation. The voltage output of a generator varies as the speed and the excitation. When the speed is decreased, excitation must be increased, and vice versa. This calls for a generator which will deliver full voltage at 40 cycles with full excitation and the same voltage at 60 cycles with reduced excitation. The function of the voltage regulator is to fit the excitation to the speed requirements. On the Coast Guard cutters the regulator operates by cutting resistances in or out of the field and is a modification of the well known Tirrill regulator.

The acid test of all engineering matters is supplied by experience and it is still too early for final judgment. The *Chelan,* the first of the new ships, had her trials in July 1928, and since then has cruised upwards of 20,000 miles with complete success and with a marked improvement in fuel consumption as compared with earlier ships.

Elaborate trials were run on the *Pontchartrain,* which was the second of the new ships, and the performance of all her machinery was measured with a high degree of precision. A complete report of her trials was presented before the Society of Naval Architects and Marine Engineers in November 1928 by Captain Newman.

The two ships are comparable as to size, tonnage, power, speed, boilers and propelling machinery. Refinements have been made in hull design of the *Pontchartrain,* and she is fitted with a contra-propeller for rectifying the propeller stream. She oper-

(Continued on page 44)

TABLE I DISTRIBUTION OF STEAM
Coast Guard Cutters MODOC (1923) and PONTCHARTRAIN (1928)

		MODOC						PONTCHARTRAIN									
Item		1		2		3		4		5		6		7		8	
1	Run No.	5		8		1		2		3		4		5		6	
2	% of Rated Full Speed	101.0		78.2		101.7		100.0		99.1		78.1		75.5		76.9	
3	% of Rated Full Power	102.1		38.8		106.6		97.8		94.6		39.8		35.5		38.5	
		Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	% of Total	Steam Lb./Hr.	[illegible]
24	Total Boiler Group	3100	7.17	1190	5.75	1836	5.10	1353	4.62	1339	4.44	898	5.35	694	4.92	847	[illegible]
25	Total Vacuum Group	3935	9.10	2100	10.13	856	2.37	635	2.17	629	2.08	614	3.65	510	3.61	537	[illegible]
26	Total Miscellaneous	2465	5.67	2755	13.31	1022	2.84	570	1.94	572	1.89	951	5.68	518	3.67	543	[illegible]
27	Excitation, Main Mach.	4260	9.86	3690	17.81	1275	3.54	789	2.69	808	2.65	1342	8.00	648	4.60	982	[illegible]
28	Stm. Used on Acct. of Aux.	13760	31.80	9735	47.10	4989	13.85	3347	11.42	3348	11.06	3805	22.68	2370	16.80	2909	[illegible]
29	Bleeder Stm. for Feed Heater					1822	5.03			2530	8.38	1128	6.72			1435	[illegible]
30	Stm. Main Turb., Prop. Only	29520	68.20	10983	52.90	29230	81.12	25983	88.54	24332	80.56	11867	70.62	11726	83.20	12636	[illegible]
31	Total Steam Used	43280	100.00	20718	100.00	36031	100.00	29330	100.00	30210	100.00	16800	100.00	14096	100.00	16980	[illegible]
32	Leakage	860		767		310		378		320		2249		268		45	
33	Total Steam Evaporated	44140		21485		36341		29708		30530		19049		14364		17025	
34	Oil/S.H.P./Hr., all Purposes, lb.	1.195		1.535		.890		.840		.823		1.183		1.079		1.11	

The National Academy of Sciences

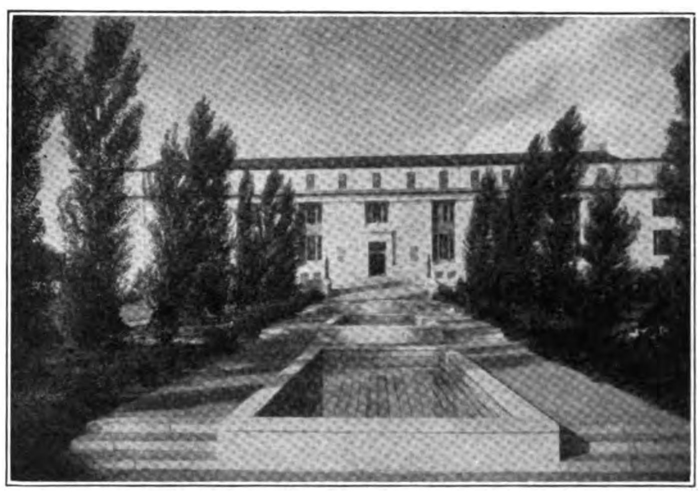
The Research Council of the National Academy of Sciences is Promoting Research of Great Importance for National Progress.

By Professor Lorande Loss Woodruff

IN 1860 when Lincoln became President, the interests of pure science in the United States were not represented by a national organization comparable to the Royal Society of London and the other great academies of the Old World; and strange to say, Lincoln became the agent for the establishment of the National Academy of Sciences of the United States of America. Strange, because Lincoln, when he entered the White House, regarded the scientific investigator somewhat as a luxury, and only gradually changed his viewpoint through the influence of Henry, Bache, Agassiz, and other leading scientists of the time, and under the dire necessity of marshaling the scientific resources of the country to meet the demands of war. So it happened that a man—born on the same day as Darwin—contributed not only to the preservation of a nation but also indirectly to the advancement of science in the United States. Lincoln supported and in due course signed the Congressional Bill incorporating the National Academy of Sciences, and thus in 1863 was founded what was to become one of the great scientific academies of the world.

The particular interest of Congress in the project is evident in the Act of Incorporation which stipulates that "the Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States."

Throughout the Civil War and later the advice of the Academy was requested and used by the President, Cabinet Members, Committees of Congress, and other agents of the Government; the members of the Academy giving freely their time and energy, although their only compensation would be the satisfaction that, to the best of their ability, they had served the government of the United States.



Building of the National Academy of Sciences and the National Research Council, Washington, D. C.

Following the Civil War period, the Academy passed through various vicissitudes, but gradually developed in power and prestige until election to its roll, restricted to 250 members, became a highly prized recognition of scientific achievement.* And it was in this position when the World War taxed the resources of the nation to cope with modern warfare. At once it became apparent that the scientific problems involved could not be solved by the small group of Academy members, but must be attacked by representatives of the varied specialized scientific fields, including the younger scientific talent of the country not represented in the Academy membership. Accordingly when President Wilson requested the Academy to marshal the scientific resources of the country for national defense, the immediate response of the Academy was the appointment of a committee which developed into the National Research Council—the latter being formally installed under the Congressional Charter of the Academy.

The success of the Council as an agent of the Academy during the War led President Wilson in 1918 to issue an executive order requesting the Academy to perpetuate the Council on a peace-time basis "to promote research in the mathematical, physical, and biological sciences and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare."

Organization and Aims of the Council.

In due course, the Council was reorganized as a coöperative body of the scientific men of America, including also a representation of men of affairs and business men interested in industry and engineering and "in the fundamental or pure science on which the applied science used in their activities depend." The Council members are appointed for a definite term of years by the President of the National Academy of Sciences, largely upon nomination by the major scientific and technical societies of the country—all societies interested in the promotion of research in the biological and physical sciences, and the encouragement of the application and dissemination of scientific knowledge for the benefit of the nation and of the world.

*The Yale Faculty is at present represented on the Academy's roll by President James R. Angell, and Professors E. W. Brown, R. H. Chittenden, E. S. Dana, Raymond Dodge, R. G. Harrison, C. S. Hastings, Yandell Henderson, T. B. Johnson, L. B. Mendel, Frank Schlesinger, Charles Schuchert, L. L. Woodruff, and R. M. Yerkes.

The Research Council is composed of a series of major divisions, one group of seven divisions of science and technology representing, respectively, astronomy, physics, and mathematics; chemistry and chemical technology; biology and agriculture; anthropology and psychology; the medical sciences; geology and geography; and engineering and industrial research; and another group of four divisions of general relations, representing foreign, Federal, State, and educational relations. Each of these major divisions comprises a series of committees, with its own special projects for study. There is also a special research information service, as well as certain other committees, administrative or technical, which affiliate directly with the Executive Board of the Council. The general administrative officers of the Council are a chairman, four vice chairmen, a permanent secretary, a treasurer, and a chairman of each of the various divisions. All of these, except the permanent secretary, are nominated annually by the executive board, or by members of the divisions with the approval of the executive board, and are appointed by the President of the Academy.

The Research Council is neither an operating scientific laboratory nor a repository of large funds to be distributed among scientific workers or institutions. It is rather "an organization which, while clearly recognizing the unique value of individual work, hopes especially to bring together scattered work and workers and to assist in coördinating in some measure scientific attack in America on large problems in any and all lines of scientific activity, especially, perhaps, on those problems which depend for successful solution on the cooperation of several or many workers and laboratories, either within the realm of a single pure science or representing different realms in which various parts of a single problem lie. It particularly intends not to duplicate or in the slightest degree interfere with work already under way; to such work it only hopes to offer encouragement and support where needed and possible to be given. It hopes to maintain the morale of devoted isolated investigators and to stimulate renewed effort among groups willing but halted by obstacles. It will try to encourage the interest of universities and colleges in research work and the training of research workers, so that the inspiration and fitting of American youth for scientific work may never fall so low as to threaten to interrupt the constantly needed output of well-trained and devoted scientific talent in the land. With any serious interruption in the output of American science and scientific workers, the strength of the Nation will be immediately threatened."†

Practical Assistance Rendered by the Council.

The methods of contributing practical assistance to American science, which the Council has so far adopted, in harmony with the general policy just outlined, are various and numerous. One is the establishment of special committees of experts for specific problems urgently demanding study. These committees outline methods of attack and attempt to secure both men and means for bringing the plans to fruition. In these endeavors they have the assistance, so far as needed, of the general administrative officers of the Council. Another is securing the coöperation of industrial concerns interested in the growth of the scientific foundations of their processes, and inducing them to support the establishment of special investigations under the advice of experts representing the Council. And still another is the stimulation of larger industrial organizations, which may be in a position to maintain their own independent research laboratories, to appreciate the advantages of contributing to the support of pure science in order to increase the basic knowledge on which the future progress in applied sciences is so absolutely dependent.

The Council's interests are even wider. It supports, through the aid of generous donors, university research fellowships, the publication of valuable scientific papers, the preparation of bibliographies and abstracts of current scientific literature, the collection and distribution of information on current research, university and industrial research laboratories and facilities, research personnel, etc., and the dissemination of popular and authentic scientific news and information for the sake of increasing the public interest in productive scientific work. These examples must suffice to illustrate the varied projects and methods of the Council.

The actual carrying out of the general program of the Council naturally devolves, in the final analysis, chiefly upon the various Divisions of the Council. Each Division is presided over by a Chairman, usually a member of the National Academy, who is responsible for the organization and work of the Division, including its numerous committees and sub-committees. Usually the chairman holds office for not more than one year. This is partly because it is difficult for eligible scientific men to remain away from their permanent positions for a longer time, and partly because the Council believes that frequent changes in personnel of the chairmen serves to prevent stagnation by introducing new points of view into the divisional activities.

Quite representative, for example, is the Division of Biology and Agriculture, of which the author was chairman last year, when on leave of absence from Yale. The personnel of this Division comprises members at large and also representatives of various technical societies including the American Society of Zoologists, American Society for Horticultural Science, American Genetic Association, Society of American Foresters, Ecological Society of America, American Association of Economic Entomologists, American Dairy Science Association, Botanical Society of America, Society of American Bacteriologists, and the American Society of Agronomy. Among the committees operating under the Division are: Committees on Animal Breeding, on Agriculture, on the Atmosphere and Man, on Family Records, on Food and Nutrition, on Forestry, on Infectious Abortion, on Pharmacognosy and Pharmaceutical Botany, on Population, on Research Publications, on Human Heredity, and on Tropical Research.

The Home of the Academy and Council.

It is clear that the Council, as it rapidly became the great coördinating and working agent of the Academy, demanded more adequate headquarters than were needed by the Academy before the Council was established. And in this emergency, thanks to generous donors, the Academy was enabled to secure a square of land facing the Lincoln Memorial, and to erect a building for the joint use of the Academy and the Council. This edifice is probably the most appropriately magnificent and serviceable building owned by any scientific society in the world. Incidentally, it may be mentioned that on the walls of the reading room there is a painted frieze of the arms of eight historic universities, arranged in order of age: Bologna, Paris, Oxford, Cambridge, Heidelberg, Leiden, Harvard, and Yale.

The home of the Academy and Council is rapidly becoming the focus of science in America. As President Coolidge, in

(Continued on page 35)

†Report of the National Research Council, 1927.

Factors Influencing Individual Capacity

Mental Conflicts, Nervous Diseases, and Other Conditions May Cause the Intellectually Gifted to Fail; While Special Characteristics May Enable the Feeble-minded to Succeed.

By Dr. William Healy

THE theme of this paper is the reciprocal relationships that exist between determinable mental capacities and other aspects of personality, not only as these bear on and modify each other, but as they are related to what may be termed the output of the individual in life activities. Many mental capacities and some personality characteristics have been evaluated qualitatively and sometimes quantitatively, the former mainly by means of mental tests, the latter in more various ways, for example, by rating scales based on judgments of the individual. Some few correlations between such measurements—as between mental capacity and leadership—have been determined by our American social psychologists. But while these researches are of value, yet it is only through well-rounded case studies embodying good physical examinations, extensive mental testing, observations concerning personality characteristics, and adequate social data, that there is opportunity for noting the interplay of capacities and personality actually in operation.

In this approach there is no belittling certain special studies, for example, of psychological types, and the whole great field of the dynamics of emotional life. Nor is there any denying that physiologists and anthropologists make contributions to this subject. And it may be that the investigations of psychobiological and endocrine types will be significant, as well as racial differentiations, and climatic influences. And we already know that some diseases establish personality patterns. Perhaps, too, the future may bring evidence that personalities can be differentiated according to nutritional influences. Thus it is already possible to make a considerable list of topical headings under which personality types and their modifications can be properly studied.

Whatever we develop in this paper we stand our ground in insisting on the absolute need that exists for taking into account all these reciprocal relationships—that is, if we are to gain any practically aimed understanding of what goes to form human personality and what conditions the output of an individual.

Let us turn directly to actual case material of individuals studied by us and whose careers are known over considerable periods and begin with some of the least complicated aspects of our topic. We may first speak of those who, according to standard age-level tests, grade as feeble-minded particularly because of the prevalent notion that if such an individual is found to be clearly mentally defective according to these standard evaluations, there is little or nothing more to be said about him—entire judgment is based on the age-level findings.

Personality Characteristics in the Feeble-Minded.

Granting that among individuals who belong on these lower levels of mental capacity, there are fewer instances of differentiations of personality and capacity than among the better endowed groups, nevertheless, we can readily show many cases where irregularities of abilities and special personality characteristics were of great significance for careers. And again we would insist that these special characteristics and capacities are not shown at all by stating the individual's intelligence quotient or mental age. We may pass over the well known facts that most of the feeble-minded are mild and suggestible, and that others are aggressive and uninhibited, or that some possess highly specialized mechanical, musical, or artistic abilities.

Two cases having special capacities and personality characteristics strikingly interplaying are the following:

A boy of almost 16 years, very carefully tested under the best possible conditions, rated no higher than I. Q. of 73. His school achievement in arithmetic was not better than 4th grade, although he had been steadily attending school since he was 6 years old. In other tests for reasoning, comprehension, and apperceptive ability he did no better than this. He handled concrete material very poorly. But his memory for words, phrases, and long passages was found to be relatively extraordinarily good. He had picked up a surprising amount of common sense information. He was a dramatic personage, and his conversation and even correct answers to tests were accompanied by flourishing gestures. In doing tasks that interested him, always verbal, to be sure, he showed much initiative, often in an exaggerated, foolish way simulating the expression of a person deep in thought. Now, this boy's whole personality development and career, we found, had been profoundly conditioned by his single good ability, namely, that of readily learning words and phrases, and by his obvious personality characteristics.

Even as a very little boy he liked to show off by reciting poems. Through his command of words he assumed authority over his comrades and even in his own household. The public discussion of the soldiers bonus bill soon after the war, with the many appeals to the people at large, gave him an opportunity to display his talents when he was only 13 years old. He became known as the boy orator. By the time we saw him he had also been engaged in making many speeches for a party candidate prior to an election. We have samples of these speeches which show that he had picked up the tricks of the political orator, and from these we can well believe that this boy was even able, when acting as chairman, to manage a meeting rather well. He has continued these interests and has already figured in several political campaigns.

A girl of 15, with an I. Q. of 68, school work on 3rd and 4th grade level, comprehension of reading less than 3rd grade, was found to be a persistent and very planful worker especially as evinced with concrete material. Her history evidenced this same ability to plan, to foresee, to use a certain amount of simple commonsense. This, together with good personality characteristics, has made her economically successful.

Friendly and responsive and always responsible, she developed many satisfactions in connection with her special abilities as soon as she was relieved from the strain of ordinary school subjects. For years she has been entirely self-supporting. Though living away from her family, she has been able to take care of herself very well indeed. She has long taught a Sunday School class and obtains her recreations in entirely satisfactory ways.

These two cases are representative of those individuals who, by virtue of certain abilities which rise above the level of their defective so-called general intelligence, together with socially

valuable peronality characteristics, are able to meet life's requirements quite adequately.

Personality Characteristics and Persons of Normal Intelligence.

Exactly the opposite is true of individuals classed as quite normal mentally where certain capacities, strongly plus or minus, immensely influence personality and output. If we had time, we could cite many instances where, for example, defective learning capacity or defective apperceptive abilities in an individual otherwise mentally normal have extraordinarily affected the individual's personality, make-up, and career.

More striking, perhaps, is the fact that superior mental capacity, even where there is high general intelligence and many good abilities, in and of itself is no guarantee of educational, economic, or social success. The group classified as having supernormal general intelligence contains many individuals whose careers can be understood only in the light of factors other than capacity. Some illustrations follow:

We have known a certain young man for more than five years. Seen first when he was 17 years old, he was found to be of keen mentality. According to various tests, he showed himself to have considerably better than average capacity in both clerical and mechanical work. With one exception he scored as high as possible on all of the tests in the Stanford revision of the Binet. His apperceptive and reasoning powers were remarkably good; indeed, he did better than average on a wide range of mental tests. He was keenly interested and not at all fatiguable during any of the tests periods.

It was soon easy to see that all this was in great contradistinction to his personality traits. He was self-deprecating, ambitionless, vague about his interests, dissatisfied, but not energetic even in his dissatisfactions. He was childishly talkative and naive, ill at ease and immature. Bodily attitudes and the postural tensions of his face showed weakness, and the fact that he was always ill at ease. All this was in direct accord with the very complete history that we received of him, especially the story of his reticence, unresponsiveness, dawdling, preference for playing with younger boys, and not holding jobs or caring to work for special promotions or honors in high school. His family and the school people were worn out, they said, by his inadequacies. Finally he was rejected from school on account of the feeling that ultimately he would not work well enough to graduate from high school.

The physical picture which he presented was that of a tall, rather slight boy with sharp but weak features, a listless, indefinite posture and gait. Particularly noted was his weak and ineffectual voice. He had been under very good medical care, and from the standpoint of any special organic or other diease, nothing had been found except that there persisted a positive Wasserman reaction as the result of congenital syphilis for which he had been thoroughly treated when he was a child and at intervals since. But one would not emphasize the latter factor too much because in most instances of such inadequate behavior there has been no evidence whatever of congenital syphilis, and in many cases where there has been clear proof of this and the Wasserman reaction has continued positive, the individual has proved himself in personality characteristics strong, adequate, and sometimes aggressive.

There has been much attempt to brace up this boy and interest him in himself. Though given every incentive earlier and since we have seen him, and though he has been punished for some transgressions by being sent to the reformatory, he still remains much the same individual, thoroughly inadequate, always taking the immediately easier path, readily led by other boys, for example, into taking joy-rides in stolen cars, the prevalent mode of enjoyment for the adventurous youths of today. This young man represents thus a case of constitutionally inferior personality, a category that has to be definitely reckoned with and one which is not indicated at all by the results of mental testing. In such cases the output of the individual is more influenced by his personality characteristics than by mental capacities.

When 11 years old an energetic, lively, alert-minded boy was spending his 3rd year in the 4th grade. With us he proved himself to have superior ability in a large number of tests; his I. Q. was 120. He had finished 3 grades in the 1st 2 years of his school life, and then came a slump. He was punished in school for his lack of attention, and when we saw him he had been truant for some time. We found that we had to deal with a remarkably sensitive, as well as a very bright boy. Gradually getting at his mental insides, it became clear that he was far from happy; some of his remarks enabled us to understand his life attitudes somewhat. "Half the time I don't know what's the matter. I don't feel sick, it's not exactly that." When asked with whom he lives, he said "I live with my father and mother, as far as I know". This statement proved to be the clue to the whole situation. From some passing remark made by a relative and through the unconscious emotional attitudes displayed by the really good man who passed as his father, the boy had sensed something unusual about his family situation. His own vague perception that there was something in the family relationships that was unusual had begun a couple of years earlier and had altered his feelings about life. His truancy was merely an exhibition of utter dissatisfaction with his school career. He wanted to leave school already and go to work; he felt sometimes as if he would like to live away from home, although he was very deeply attached to his mother who had always been good to him. He gave various instances of why it seemed to him that somehow his father did not act exactly like a father.

Digging into the situation for the sake of the boy, we found that he really was the illegitimate child of this mother who was as deeply attached to him as he was to her.

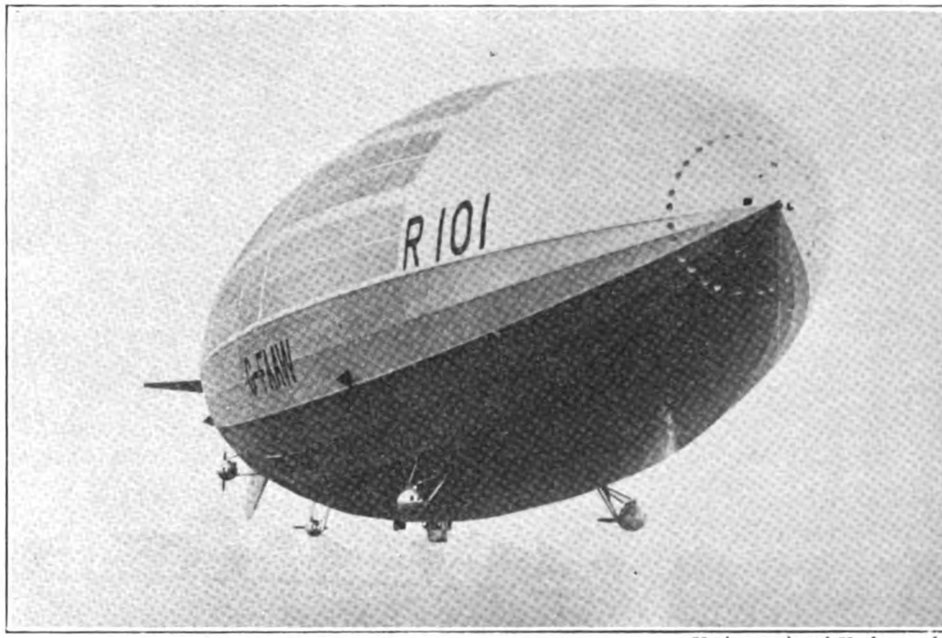
In spite of the fact that the home life was essentially good and that the step-father was a kind man, the boy had to be placed in a foster home before he began the good school advancement of which he was so eminently capable. The reason for his poor output was totally non-understandable without knowledge of the deep, and, for the most part, unconscious mental conflict that was assailing him.

Disease and Personality.

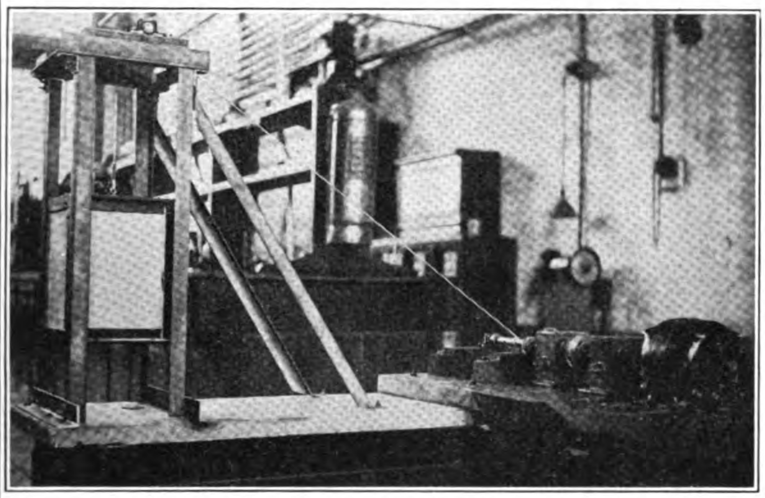
Psychologists who are interested in human nature, whether in relation to clinical practice or not, cannot afford to neglect the information concerning the basis and differentiation of personality characteristics which may be gained through a study of cases of encephalitis lethargica. It has long been clear to us that pathological material in the field of psychology might be utilized to gain greater knowledge of the normal in ways parallel to the developments in physiology where much has been learned through the study of physical disease. For example, through study of the feeble-minded much light might be thrown upon normal mental development. One can but be impressed by what has been done in this way by Dr. DeCroly who has made his long observations upon mental defectives and utilized them in

(Continued on page 32)

RIGHT.—*The new British dirigible, R-101, on a test flight at Cardington, England. This huge ship embodies a number of new developments in airship construction. Stainless steel is used for much of the framework, being said to be lighter for equal strength than duraluminum. Five 585 H. P. Beardmore Diesel engines burning heavy oil are installed, one being used for reversing only, although it is planned to fit a variable pitch propeller for reversing. These, the first Diesels ever used in a dirigible, weigh about 8 lb. per horsepower. The gas bag has a capacity of 5,000,000 cubic feet, is 732 feet long and has a maximum diameter of 132 ft. The two decks of passenger cabins, the windows of which may be seen above the letters, G-FAAW, have accommodations for 52 passengers.*

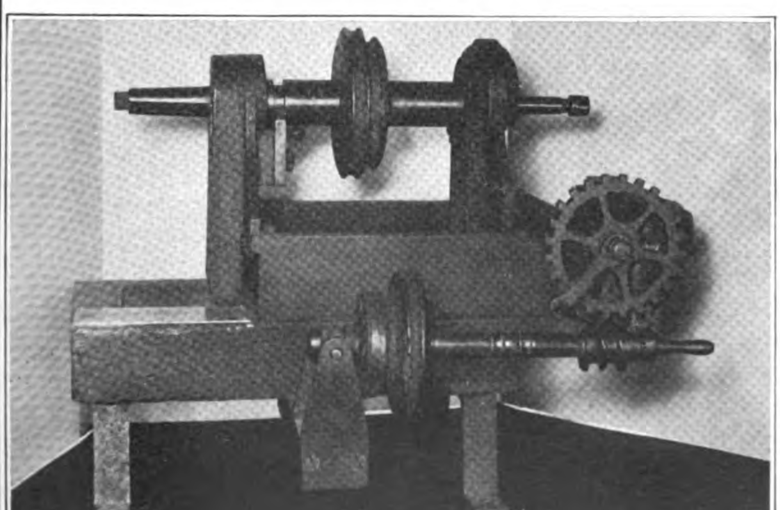


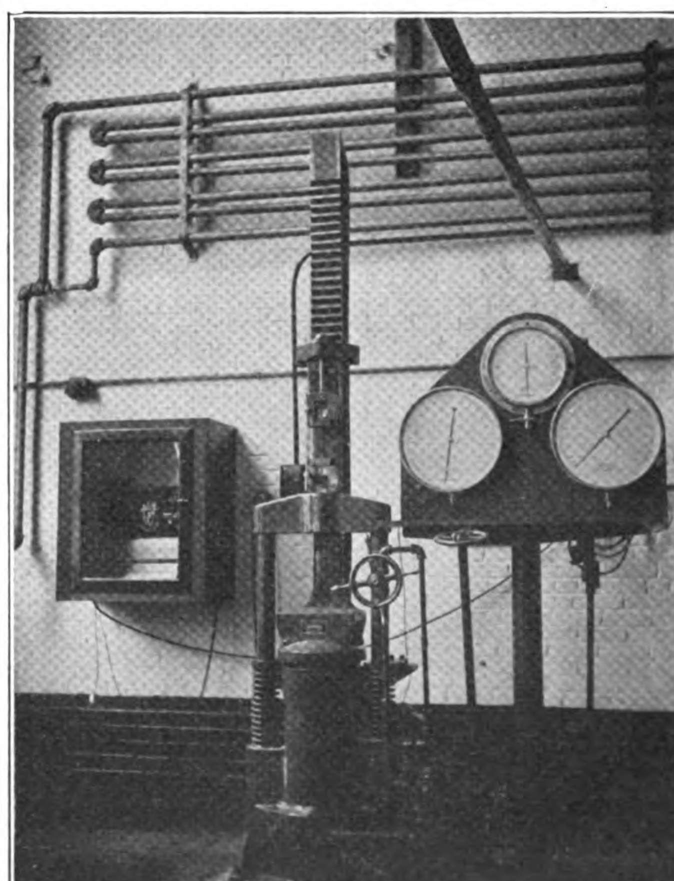
Underwood and Underwood.



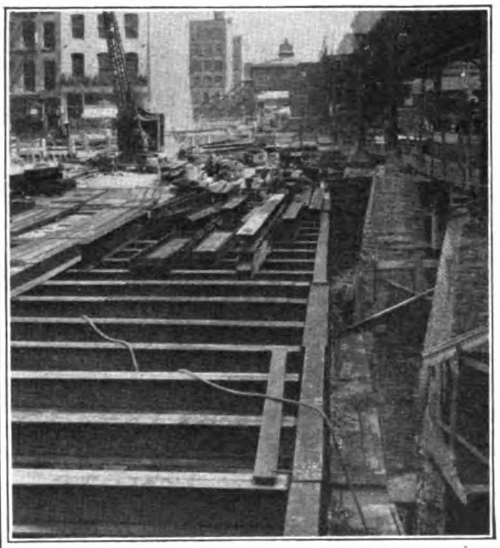
LEFT.—*An electric furnace in the Hammond Laboratory which can be raised or lowered at extremely slow rates by means of a gear reduction unit. The heated furnace passing a stationary piece of metal gives a uniform rate of cooling, which is necessary for the formation of single crystals.*

BELOW.—*A milling machine built by Eli Whitney about 1818, to manufacture muskets for the U. S. Government. This machine was in the shop of the Whitney Arms Co., New Haven, until 1888, lay for 26 years under a hay-mow, was taken to Yale University in 1926, and placed by them in the Museum of Peaceful Arts, New York, in 1927. It is probably the oldest machine in existence used for interchangeable manufacture.*





ABOVE.—*A 20,000 pound Southwark-Emery hydraulic tensile testing machine recently installed in the Hammond Laboratory. The load on the piece being tested is recorded by the apparatus in the cabinet at the left.*

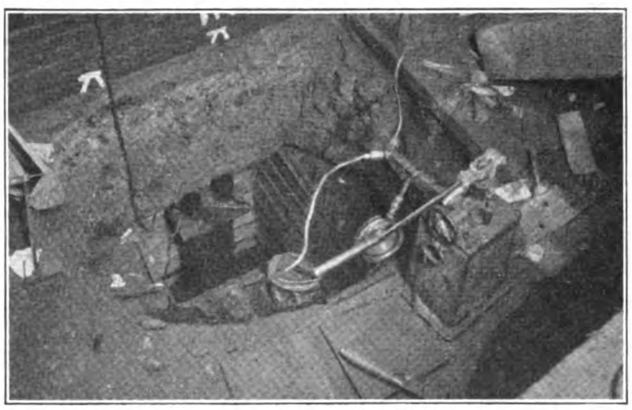


ABOVE.—*Church Street was widened from 30 ft. to 90 ft. to make possible the use of four tracks on one level instead of the more expensive two level construction. The method of supporting the new street surface is well shown here.*

NEW YORK'S NEW SUBWAY.

The new subway system now being built for the City of New York to be operated by the City Board of Transportation as a partial solution of New York's complex transportation problem. Fifty-seven route miles costing over $500,000,000 are now completed or are under construction. It is expected that partial operation will begin in 1931.

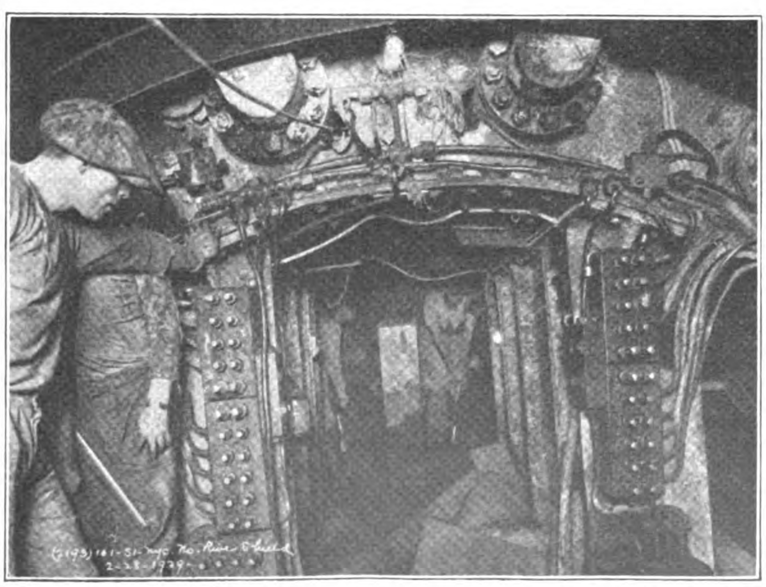
ABOVE.—*Some idea of the difficulties of construction may be gained from this view of Cathedral Circle looking west. Water mains, telephone cables, sewers, power and light cables and gas mains must all be taken care of without interrupting street traffic. A gas main, by-passed overhead, may be seen here. The Elevated R. R. structure in the upper right corner had to be carried on the subway roof, the load being shifted as shown below.*



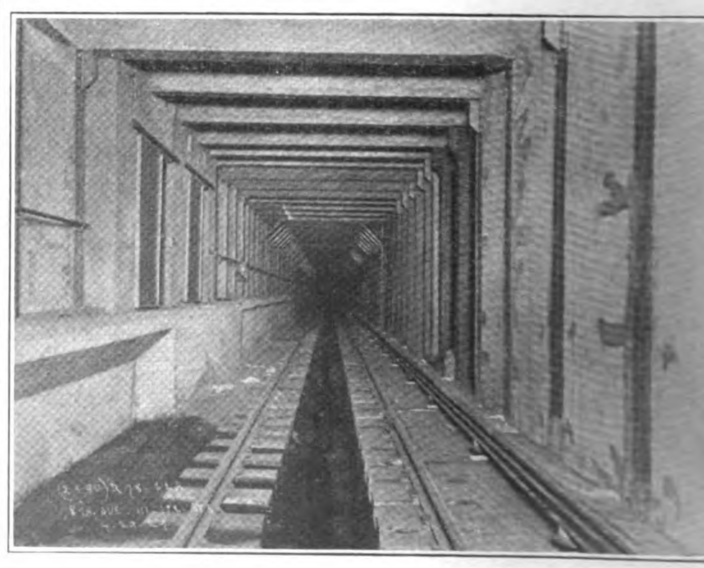
LEFT.—*"Picking up" an elevated column by means of hydraulic jacks. 99 pillars on 8th Ave. from 110th St. to 122nd St. had to be supported by bracing from the sides while the subway was being built with affecting service. The weight was transferred to the roof beams of the completed subway with the aid of jacks. In no case was the alignement of the elevated structure changed as much as one sixteenth of an inch.*

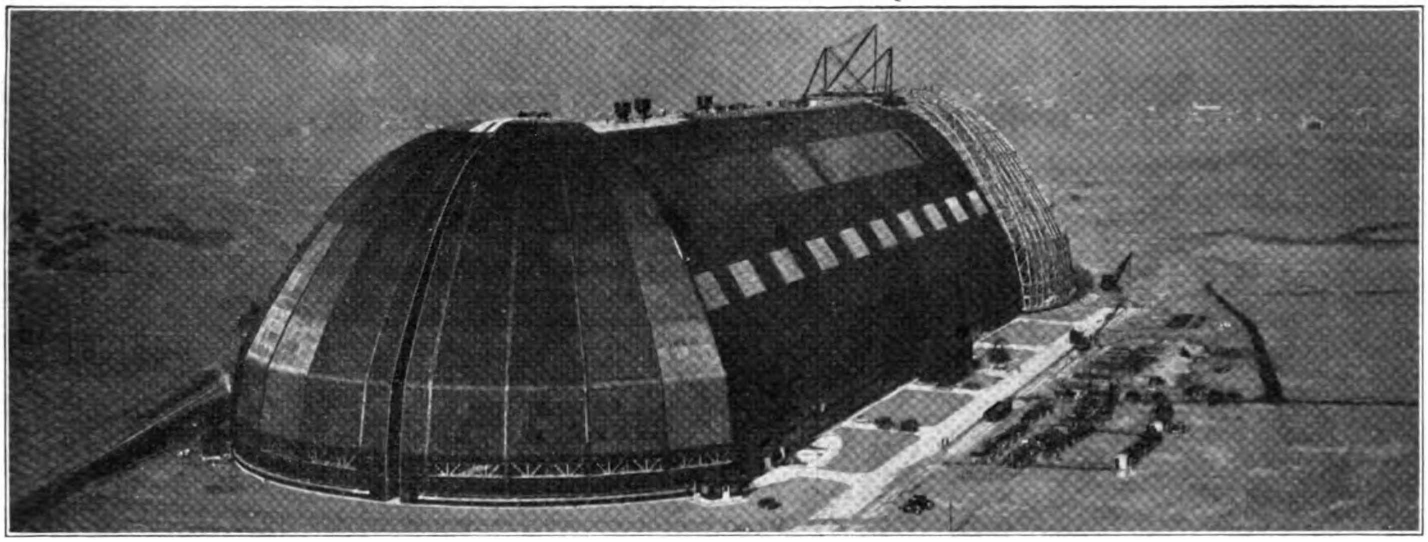
RIGHT.—*Under St. Nicholas Ave. the lines are on two levels to eliminate a grade crossing where the Bronx Division fork leaves the main line.*

BELOW.—*One of the shields used under the East River. This view from the rear shows "sand hogs" digging in front of the shield. Two of the hydraulic jacks which push the shield forward as the earth is dug from before it may be seen at the top of the picture. As the shield advances, sections of cast iron lining are placed behind it.*



BELOW.—*A completed section of the 8th Ave. line under Cathedral Circle. The third rail may be seen to the right of the right rail. The platforms and third rails of this subway system are designed so as to make possible the use of the type of equipment used by the B. -M. -T.*

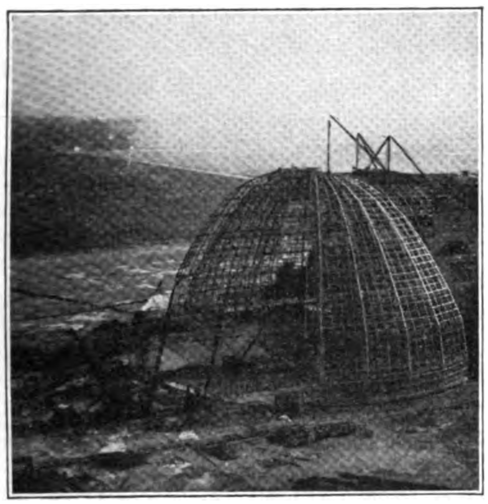




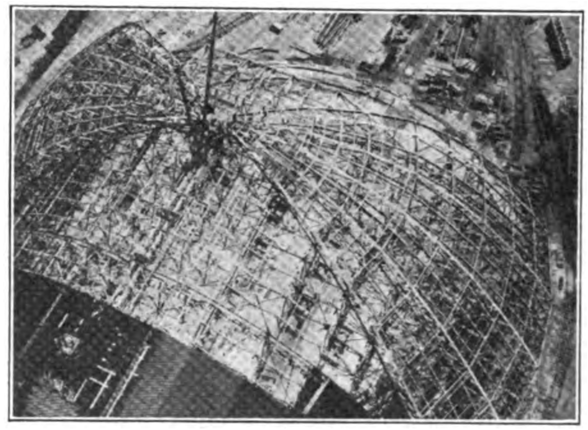
THE GOODYEAR AIRSHIP FACTORY AND DOCK.

The airship hanger recently completed for the Goodyear Zeppelin Corporation at Akron is intended to house two 6,500,000 cu. ft. dirigibles. It is 1175 ft. long, 325 ft. wide and has a clear inside height of 180 ft. The parabolic section was adopted because of the decreased wind disturbances created by this shape.

ABOVE.—*An exterior airship view showing the nearly completed dock. This photograph was taken from the southern end of the structure and shows the building almost entirely covered over with the exception of the doors at the northeast end. In the background is shown the Akron Municipal Airport on which the dock is located.*

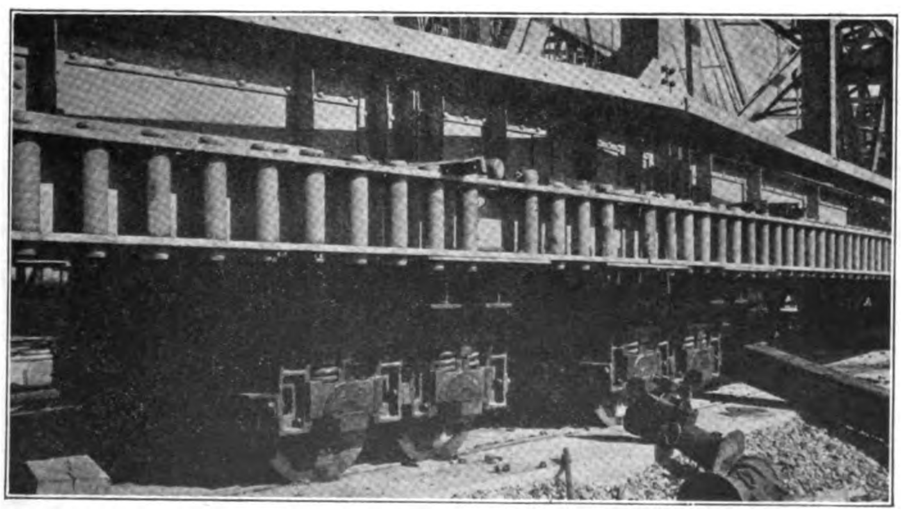


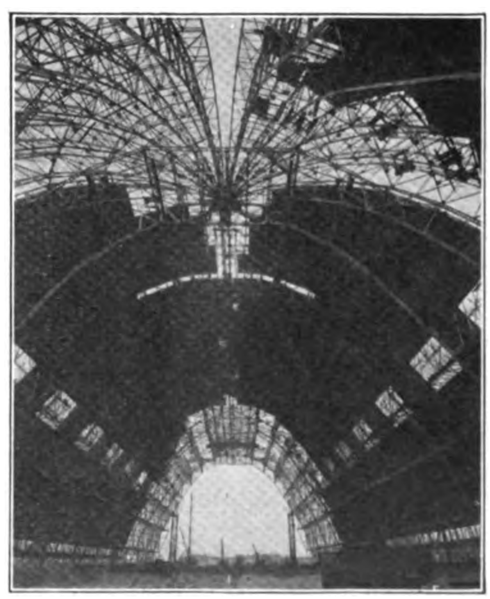
LEFT.—*This view was taken from an airship at the northeast end of the dock and shows the uncovered structure of the doors. They are in the shape of a quarter of an orange peel and rest on a number of standard railroad trucks which facilitate their opening and closing. Each of the two leaves of each door weighs six hundred tons. Several of the locomotive cranes which erected the entire framework are shown in front of the door.*

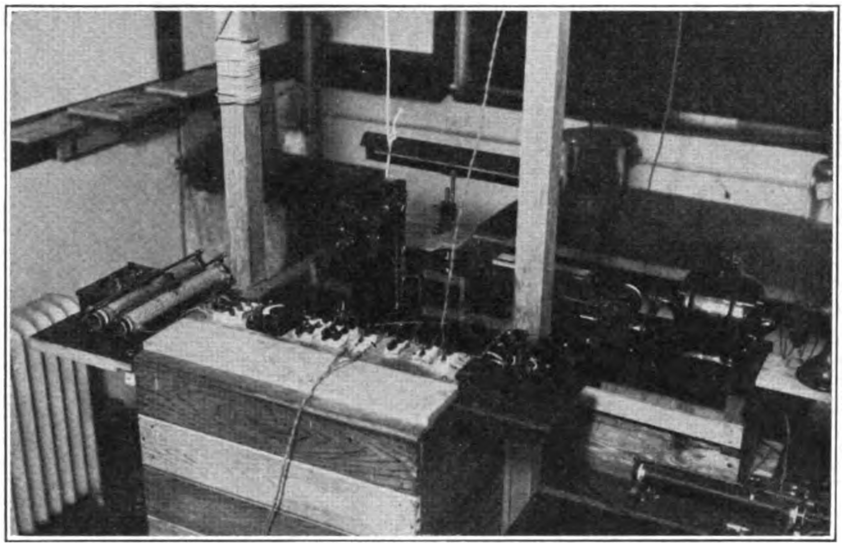


BELOW.—*A view of the interior of the partly completed structure showing the inside of one of the doorframes.*

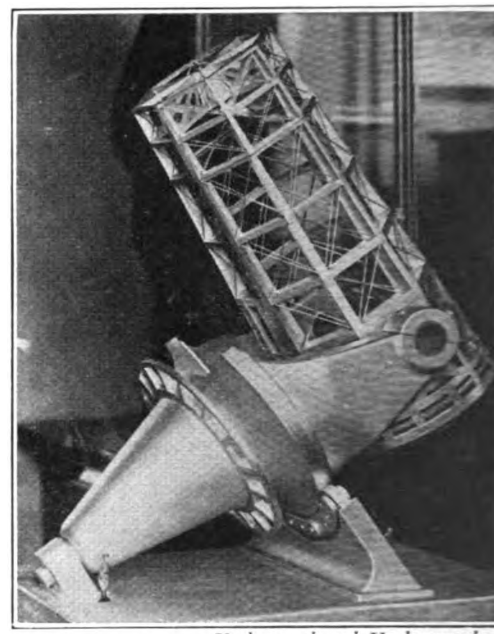
BELOW.—*This photograph shows the pin rack which operates one of the leaves. A 125 H. P. motor equipped with automatic brakes and cut off switches is used to drive each rack through a pinion 60 inches in diameter.*







ABOVE.—*This copper-lined oil-filled thermostat in the Sloan Physics Laboratory contains two similar wires, 50 cm. long, so supported in solemoidal coils that one may be magnetized, elastically stretched, or both, while its electrical resistance is accurately measured. Changes in resistance depend partly on the imperfect symmetry of metal atoms.*



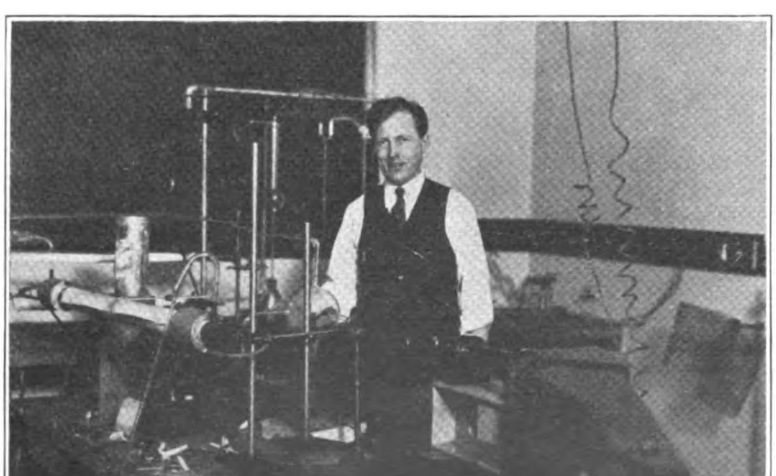
Underwood and Underwood.

ABOVE.—*A model of the 200 inch telescope now being constructed for the California Institute of Technology which will be, upon completion, the largest telescope ever built. The mirror alone is to weigh thirty tons. With this instrument nebulae 280,000,000 light years distant may be studied.*

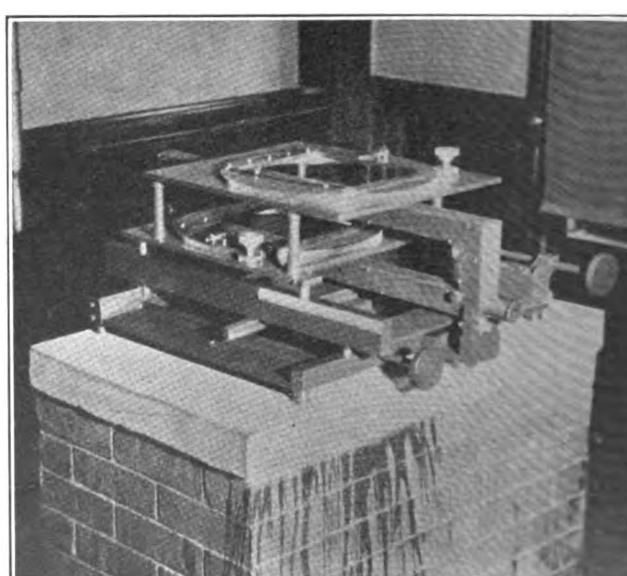
Underwood and Underwood.

LEFT.—*One of the low powered tailless planes now being experimented with in Germany. This plane shown at Templehof Field near Berlin was designed by Herr Espenlaub. Machines of this type with engines of only eight horsepower have made speeds as high as 78 M. P. H.*

BELOW.—*Apparatus in the Sloan Physics Laboratory upon which experimental work in the study of isotopes is being done by Assistant Professor W. W. Watson, who is shown here. With similar apparatus it has been shown that oxygen is composed of atoms having atomic weights of 17 and 18 besides those of the much more common 16.*



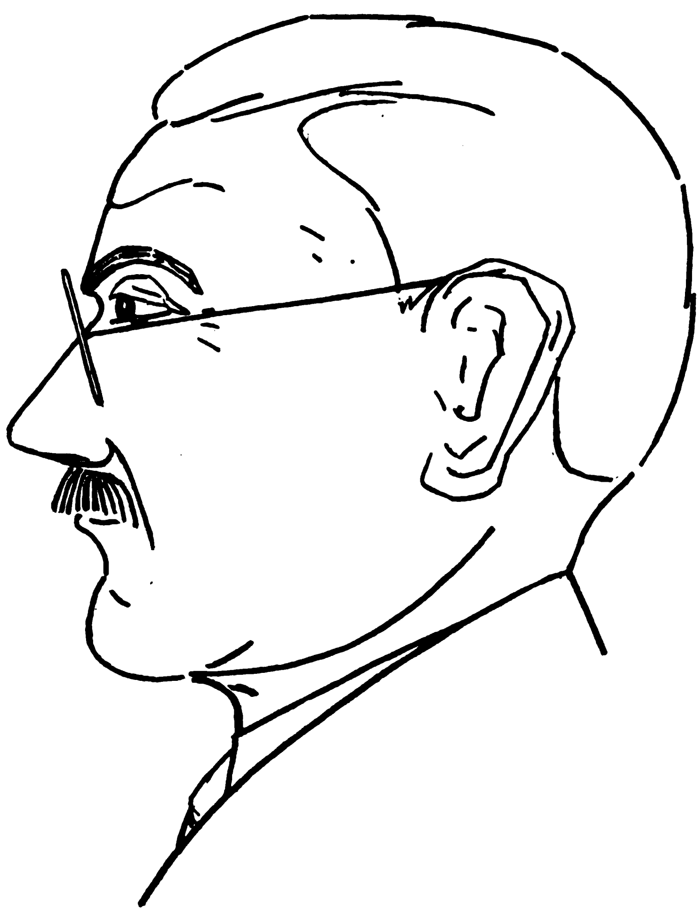
BELOW.—*A comparator for stellar photographs. This machine enables two photographs taken at different times to be quickly compared. Much astronomical research now depends upon making such comparisons. Four of these machines have been constructed at the Yale Observatory shop for other institutions.*



P·E·R·S·O·N·A·L·I·T·I·E·S

JOHN ZELENY

TO a large number of students in any institution physics means something that requires brains to comprehend but must to most of them forever remain somewhat supernatural. The former is a fact but the latter is a myth which, sooner or later, is realized as such by the students themselves in Professor Zeleny's classes in the Sheffield Scientific School. The members of his undergraduate classes are men who are not preparing for the engineering work for which physics is essentially fundamental, but they are men who have other scientific aims, the attainment of which does require some foundation in the basic science of physics. As these men come for the first time to that fine Gothic structure known as the Sloane Physics Laboratory they are possibly already in possession of some legends passed on by their fathers or grandfathers or released in the prep schools; for legends there are about physics, the country over. The psychological effect is unfortunately a handicap and when the Sheff man first sees the pleasant personality of the subject of this sketch and hears him expound in intelligible language the explanation of the experiments of his lectures, he begins to wonder whether *really* the physical laws are so simple as he hears them presented to him. A few make up their minds that some sort of a "first approximation" must have been worked out for their special benefit and that the real thing is different. However, suppose you attend or visit the lecture room and judge for yourself.



Professor Zeleny's abilities are partly native and partly developed by hard application to his work. He is one of four brothers who took to the sciences: one to engineering, one to biology and two to physics. His instructor at the University of Minnesota was Dean Frederick S. Jones who saw in John Zeleny a promising physicist and a scholar and did all he could to guide and help him and later made him his colleague. That he was not mistaken in him is verified not only by his accomplishments but also by the verdict of the Minnesota University alumni who in 1917 voted John Zeleny as the most distinguished alumnus of their alma mater and many of them desired his appointment as the president of the university when George E. Vincent resigned as president to become the head of the Rockefeller Foundation.

John Zeleny was born in Racine, Wisconsin on March 26, 1872 and is of Czech ancestry. His early education was received at Hutchinson, Minn. He entered the state university in 1888. As a junior in college he was one of the editors of the annual "The Gopher" and in his senior year he was elected to both the Phi Beta Kappa and the Sigma Xi Societies. His course of study was in the physical sciences.

After graduation he was made an instructor of physics and in 1896, assistant professor of physics. In 1897 he went abroad to study, spending half a year in Berlin and two years at Cambridge where he was a member of Trinity College and carried on research work in the famous Cavendish Laboratory under the noted physicist Sir J. J. Thomson. It was at a time when modern physics was born. Sir J. J. Thomson discovered the electron, Becquerel radioactivity, Röntgen X-rays, and Pierre and Marie Curie radium. Sir J. J. Thomson laid the foundations for the study of the ionization of gases and what is, at least, equally important, attracted to his laboratory such men as Sir Ernest Rutherford, the present Cavendish professor at Cambridge, C. T. R. Wilson, also professor at Cambridge, the present Lord Rayleigh of London, P. Langevin of Paris, J. S. Townsend of Oxford, H. A. Wilson of Rice Institute and John Zeleny; all men who individually have attained prominent recognition for their researches. Zeleny's work at Cambridge, the study of the ionization of gases, was important in that it showed that the positive and the negative ions concerned in the conduction of electricity through gases are not alike and move through the gases in definite electrical fields with different speeds; he measured their mobilities by a method that is at once simple and also the most natural; using currents of gas on these gaseous ions moving in electric fields.

His research work has been mainly concerned with the properties of ionized gases, photoelectric effects, electrical discharges from pointed conductors and from liquid points, instability of electrified liquid surfaces, striated electrical discharges in rarefied gases, propagation of smell, vapor pressure of solid and liquid carbon dioxide and electromagnetic rotations. He is a member of many scientific societies and has served as an officer in some of them. He also filled the position of an associate editor of the

(Continued on page 37)

Civil Engineering

There are seven students enrolled this year for graduate work in Civil Engineering.

The fall meeting of the American Society of Civil Engineers, held at Boston in October, was attended by Professors Tracy, Bishop, Farnham, and Kirby, also by president Kaehrle and Secretary Battles of the Yale University Student Chapter of the Society. In the conference on student chapters, held in connection with this meeting, Professor Tracy led a discussion on "The Responsibilities of the Faculty Sponsor."

Mr. William Joshua Barney, president of the Barney-Ahlers Corporation, addressed the meeting of the Student Chapter of the A. S. C. E. on November 11, on "The Relationship between the General Contractor and His Banker." The talk was replete with illustrations drawn from his wide experience.

Professor Crane devoted last summer to an architectural tour of Spain. He returned with more enthusiasm for the richness of the architectual treasures than for the summer climate. The Architectural Forum published last summer a series of three articles by Professor Crane on "Choosing the Structural System and Material."

Professor Kirby's "Fifth Study of Motor Vehicle Accidents in the State of Connecticut" was issued by the Yale University Press in September.

Botany

Prof. George E. Nichols attended the meetings of the Botanical Society of America at Kansas City during the Christmas recess.

The U. S. Dept. of Agriculture has established a branch of the Office of Forest Pathology, Bureau of Plant Industry, at New Haven, in cooperation with the University. Dr. Rush P. Marshall is in charge and with him are associated Dr. Glenn G. Hahn and Mr. J. R. Hansbrough.

Prof. Carl G. Deuber recently broadcast three botanical talks from WEAF and WJZ, as part of a series given by members of the staff of the Bartlett Tree Research Laboratory. The subjects were "Autumn Coloration", "Leaf Blights", and "Tree Feeding".

Astronomy

Dr. Schlesinger, director of the observatory, was one of the two American members attending the sessions of the Committee of Fifteen for the revision of the statutes of the International Research Council, at Paris during the last week of September. The Council has now been in operation for ten years and in that time has created eight International Unions (Astronomy, Geodesy, Mathematics, Chemistry, etc.) for the promotion of international cooperation in science. These Unions are universally recognized as the media for the interchange of opinions and proposals in their respective fields.

Biology

Professor Basile Luyet of Florimont, Petit-Lancy, Geneva, a bio-physicist, has been added to the research staff of the Department of Zoology and is conducting experiments upon the reactions of living material to electrical phenomena. This work promises to be of prime importance in the investigation of the fundamental underlying properties of protoplasm.

The meetings of the International Academy of Science were held at Princeton University, Princeton, New Jersey, on November 18 and 19. The laboratory staff was represented by two members, Professors Woodruff and Harrison.

The Journal Club of the Zoological Laboratory has started its meetings for the year. These meetings promise to be most interesting and instructive to the staff and graduate students since it has been planned to have visiting lecturers from other universities in addition to the members of the staff already available for lectures to this group. Professors Petrunkevitch, Coe, and Woodruff have already lectured and the series promises to be an extremely fruitful one for the year.

The recent publication of the "Origin of the Earth and its Inhabitants", a compilation of Sigma Xi lectures, edited by Professor George A. Baitsell, has appeared from the Yale University Press. The sale of this book has been so phenomenal that the previous edition has been completely exhausted and shows the tremendous public interest which is at present aroused concerning this pressing biological problem.

Physics

A biographical memoir of Professor H. A. Bumstead, the first director of the Sloane Laboratory, written by Professor Leigh Page has been published by the National Academy of Sciences. A similar memoir of Professor B. B. Boltwood, the late Professor of Radio-Chemistry, written by Professor A. F. Kovarik is also being published by the National Academy.

Professor R. B. Lindsay has a paper in the September number of the Physical Review on "Connectors in Acoustical Conduits", and one in the November number of the Journal of the Optical Society on "The Significance of Boundary Conditions in Physics."

Professor L. W. McKeehan has a paper on "The Measurement of Magnetic Quantities" in the October number of the Journal of the Optical Society and has another paper ready for the press on "The Effects of Elastic Strain and of Magnetism on the Electrical Resistance of Iron-Nickel Alloys".

Joseph H. Howey has in press a paper on "The Magnetic Properties of Condensed Films of Nickel and Iron".

A new Cincinnati milling machine is being installed in the shop of the laboratory.

Mining and Metallurgy

At a meeting of the Mining and Metallurgical Society held on November 6, 1929, the following were elected officers of the Society to serve during the current school year:

Chairman—W. R. Jennings, 1930S.
Vice-Chairman—F. K. Wilson, 1931S.
Treasurer—D. W. Smith, G. S.
Secretary—D. C. Jillson, 1931S.

A pneumatic shaking table is being constructed in the Ore-Dressing Laboratory. This apparatus is designed for the dry-cleaning of coal or the concentration of other dry materials.

A Southwark-Emery 20,000 pound testing machine has been installed in the Hammond Laboratory.

Professor R. K. Warner will attend the annual meeting of the American Mining Congress at Washington on December 4th. At this meeting there will be a special session dealing with the problems of mining education.

Electrical Engineering

Professor A. E. Knowlton spent the months of July and August as a member of the editorial staff of the Electrical World, the weekly technical-business journal of the electrical industry.

Professor A. E. Knowlton has been appointed to several of the committees of the American Institute of Electrical Engineers including Meetings and Papers Committee (Chairman), Publication Committee, Committee on Coordination of Institute Activities, Award of Institute Prizes (Chairman), and Committee on Instruments and Measurements.

In the National Electric Light Association he will serve as a member of the Power Systems Engineering Committee.

Professor H. M. Turner has been appointed by the President of the Institute of Radio Engineers, with two other scientists, to arrange for the technical program at the Annual Convention in Toronto next June. The Convention will be International in scope.

A paper by Professor Turner on "The Characteristics of Audio Transformers" was published in the September Proceedings of the Radio Club of America and one on "Inductance as Affected by the Initial Magnetic State, Air-Gap and Super-posed Currents" in the October Proceedings of the Institute of Radio Engineers.

A paper entitled "A New Furnace for Heat Treating High Speed Steel" by Professor W. B. Hall appeared in the September Transactions of the American Society for Steel Treating. This paper concerns itself with one type of the conductively heated salt baths which he has been developing for the past year or two.

Mr. W. W. Sherwood, instructor, was engaged during the past summer in the research laboratory of the Automatic Signal Company.

Mr. F. J. Beck, instructor, spent the past summer in the research laboratory of the General Electric Company at Schenectady, on the study of oxide coated cathodes in mercury vapor.

Chemistry

Professor Max Bodenstein of the University of Berlin, one of Europes foremost scientists, delivered a lecture on November 15, 1929 on Chemical Action of Light.

(Continued on page 34)

Forestry

Dean Graves read a paper on "The Expansion of Public Forests" at the annual meeting of the Society of American Foresters at Des Moines, Iowa, on December 30.

Plans are being formulated for the Third Decennial Reunion of the Alumni of the Yale School of Forestry on February 21-22, 1930. The afternoon session of the opening day is to be devoted to a discussion of the needs and future plans of the School, and will be followed by a general banquet in the evening. The morning of the second day is to be given over to a discussion of the progress and future of the forestry profession, while that afternoon a field excursion will be made to the Maltby Plantations on the Eli Whitney Forest, the property of the New Haven Water Company.

Intensive study is being made of the recently acquired collection of Liberian woods which was obtained by Mr. G. Proctor Cooper, Field Assistant in Tropical Forestry, from the properties of the Firestone Plantations Company.

The Liberian wood specimens bring the total in the Yale collections to 16,000, representing 1650 genera of 170 natural families. This is by far the most extensive assortment of woods in the world and nearly every country of the earth is represented. More than 2000 samples, many very rare, were added during the past year from the West Indies, Mexico, Central and South America, Japan, Siam, Java, New Caledonia, Papua, New Guinea, Norfolk Island, Australia, and all parts of Africa. Yale is co-operating with Oxford in an expedition to southern Africa and with the Field Museum of Natural History, Chicago, in an exploration of the forests of the Peruvian Amazon. The specimens are being systematically studied by students and scientists at Yale, and selected lots are sent to foreign institutions for special investigation. Eventually there will be no such thing as an unknown wood, living or fossil.

The annual 20th Engineers Memorial address will be given the latter part of February by William B. Greeley, who will speak on some of the economic problems of the West Coast lumber industry. Mr. Greeley, who is a graduate of the School of Forestry, is Secretary-Manager of the West Coast Lumber Manufacturers Association; he was formerly Chief Forester in the United States Forest Service and during the War was Lieutenant-Colonel in command of the 20th Engineers.

Mechanical Engineering

Professor E. O. Waters, at a meeting of the American Society of Mechanical Engineers held at Akron, Ohio, October 21, 1929, contributed a paper on "Stresses and Deflections in Flat Circular Plates with Central Holes," by Wahl & Lobo.

Professors W. J. Wohlenberg and L. E. Seeley were present at a meeting of the Fuels Division of the American Society of Mechanical Engineers, which was held at the Bellevue Stratford, Philadelphia, Pa., from October 7 to October 10, 1929.

Professor E. H. Lockwood is continuing his research in regard to the measurement of air resistance of automobiles, assisted by graduate students of the Department of Mechanical Engineering.

The New England Section of the Society for the Promotion of Engineering Education was entertained at Harvard University, Saturday, November 9 with Yale representatives consisting of Professors C. F. Scott, H. B. Hastings and E. H. Lockwood. Additional Yale men speakers on the program were George A. Stetson, '10S and P. W. Swain, '13S.

The Board of Investigation and Coordination on engineering schools in the United States and Europe, of which Professor Scott is Chairman, has just concluded a six years survey of the etire field of engineering education from which significant results already have been reported.

Professor Waters is continuing his work with the H. G. Thompson and Son Co., manufacturers of band and hack saws. The work involves miscellaneous problems in plant engineering and labor saving methods, and a general study of the efficiencies of different forms of metal-cutting saws, as determined by the cutting speed, pressure on the saw, form and size of tooth, and kind of lubricant used.

A new edition of Streeter's Internal Combustion Engines has been published this fall by McGraw-Hill Book Company. The new edition is a thorough revision by Prof. L. C. Lichty, of the Mechanical Engineering Department. Throughout the revision it has been kept in mind that the interest in internal combustion engines, at this time, lies chiefly in the liquid-fuel engine of automotive and aircraft type.

Attention is called to the fact that the advance made in the past few years in the performance of internal-combustion engines has not been due to the development of many new principles, but to a better understanding of those principles which have been known to many en-

(Continued on page 34)

How Science Discovers Rare Trees

The Scientific Field Work Now Being Done by the Department of Tropical Forestry in Obtaining New Specimens.

By G. Proctor Cooper, III.

THE Department of Tropical Forestry, Yale University, has assembled in its files the most extensive and complete collection of woods—especially those of tropical or subtropical origin—to be found anywhere in the world. This fact is known more or less generally, at least by those persons interested in woods or having to deal with important timbers and logs.

But just how all this material was gathered and assembled, classified and identified, examined and studied, with the information put on file and made available in publications, is a feature but vaguely if at all understood.

What a gap to bridge from the standing tree in the tropical bush to the finished piece of seasoned wood in the files, and the sheets of pressed and mounted leaves, flowers, and fruits in the cabinets—the latter taken from the identical trees as many of the wood specimens. A gap not only in physical distance of thousands of miles and months in time necessary for transport, but also in the multitude of steps and details necessary in bringing out the material from the bush and getting it to the laboratory where the process of identification and preparation begins. It may be of more than passing interest to know something of the procedure in transforming specimen trees in the bush to finished samples in the laboratory.

Fig. 1. The boys ready to come in (they have their shirts off when working).

Once on the ground, headquarters must be established at some central point which will allow easy access to the seaport and yet not be far from the forest. Generally some planatation house or camp can be borrowed for the purpose and it is often fitted up for immediate occupancy. Equipment must be set up or built to suit the requirements or the work, stores must be acquired, personnel recruited, interior transportation routes studied, and means of travel by land and water must be procured.

In Central America there are almost no roads or highways outside of the cities, and those few which do exist are of the "dry weather" type. Transportation is by narrow gauge railroad, mule and horse, or by foot. In West Africa there are railroads penetrating the interiors of all the British and French colonies, but none at all in Liberia. There are also highways in most of the colonies along the coast, but rarely leading into the interior. Until a few years ago there were no roads at all in Liberia, and the narrow, winding dirt road that was in use when the Firestone Plantations Company began operations there had to be repaired and widened and built up for almost its entire

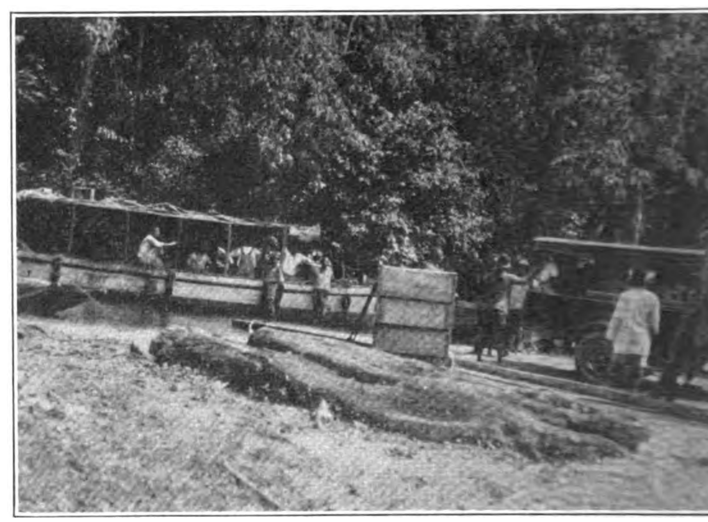


Fig. 2. The Expedition uses various means of Transportation to bring out its specimens: Dugouts, launches, and trucks.

length before it could be used to transport goods into the rubber land. Today, the roads on the Company holdings are the finest on the entire coast, and the government highway has now been raised above flood level so as to be serviceable throughout the entire year. But getting around in the forest in West Africa is a problem because there are almost no horses or mules in the lowlands. The presence of the tse-tse fly, carrying the sleeping sickness germ, prevents the keeping of stock for riding or hauling. The white man either walks with his bearers or is carried in a hammock or sedan chair under a canopy which protects him from the fierce heat of the sun. When bearers are used in West Africa to carry the equipment and supplies, a large amount of food must be taken along to feed them unless there is a reliable supply in the region through which one is travelling. Native porters passing through territory of traditional enemy tribes will not touch the country food until it has been eaten by the village head man as proof of its quality, because the practice of killing the enemy by the subtle use of quick-acting poisons is still in vogue in parts of the interior, especially where the natives are cannibalistic in their diet. And it is advisable *not* to take porters belonging to the same tribe living in the interior districts through which the expedition must pass, for many of the boys will desert and run away when they find themselves among

YALE ENGINEERING ASSOCIATION

old friends and sweethearts, the loss of pay balanced by whatever loose equipment they can carry off with them. When mules are used in Central America, especially when going up the narrow mountain trails, a supply of grain must be carried because there is no grazing or forage under the forest cover, and the animals must be sent back to the lowlands when the objective is reached to wait there until word comes by bearer that they are wanted for the outward passage.

The question of sanitation and hygiene is vitally important to both the white man and his native helpers. Fevers and intestinal parasites are so much a part of the native life that he is more or less indifferent and apathetic in his attitude toward illness, being naturally of a fatalistic nature anyway. The success or failure of an expedition may be directly due to the health of the members, and when doctors are sometimes "a week's walk" away, the practice of preventive medicine is highly important. We sleep under nets as a guard against malaria and yellow fever mosquitoes; boil and filter the water to kill any dysenteric germs; carefully examine and prepare the country vegetables and fruit (so necessary in the fresh state as a relief from the tinned variety) to eliminate the ascaris and tape worm; frequently use antiseptics in spraying the living quarters and the ground in the vicinity of the camp to kill the hook worms which enter the human body through the soles of the feet; and constantly scour the camps and kitchens to keep the filthy cockroaches and vermin at a mimimum. And, of course, there is the daily five grains of quinine as a prophalactic, and the regular dose of alkaline salines to counteract the gastronomic disturbances set up by the continual use of canned food.

One way to gather woods and botanical material is to follow a felling operation that is clearing the jungle for planting bananas, cacao, or rubber, or perhaps an engineering line that is being surveyed. Those trees in bloom or in fruit are picked out and the material selected. This saves a lot of work in chopping down the larger trees. Great care must be exercised, however, for when the crown and the stump are perhaps a hundred feet apart, and there are twenty or thirty trees in the jumbled mass, it is often difficult to trace the bole from the top to the base where the wood sample is to be taken. Occasionally, in spite of all precautions, wood samples and leaves are gathered accidentally from quite different trees, and this, of course, causes much confusion.

Detailed field notes are taken on the ground so that all features can be properly and accurately noted. Typical sprays of leaves, flowers, and fruits are gathered, together with a block of wood containing bark, sapwood, and heartwood. All this material is given the same serial number which appears for this particular tree and no other. The difference in species is often imperceptible to the field man and to group together several trees which he thought to be identical would only lead to great confusion and cause the material to be valueless. When fruits or seeds are picked up from the base of the tree they are always noted as such, even though it is quite certain that they belong to the tree in question, for in case of a mixup, the botanist might assume the material to come from the branch of a certain tree for which it did not fit at all. This material is taken to the camp and sorted out immediately and then placed in sheets of paper about one foot wide and a foot and one half long when folded. This jacket is placed between two corrugated boards of the same size and in this way a pile of leaves and flowers can be built up which will be about a foot thick when tightly strapped between wooden frames. A method which the Yale University expeditions are now using is to make an improvised oven from a five-gallon kerosene tin bv opening the sides and bending the tin from one side out and from the other side inward. If this is placed over a low flame or on a stove, the hot air will pass through the tin and up through the corrugations of the boards. This will create a considerable amount of very hot dry air and in twenty- four hours all but the fleshy fruits and leaves will be bone dry. This is a marked improvement over the old method of sun-drying the material which necessitates changing blotters and jackets daily or more frequently for a period of two weeks or more. When five to ten specimen sheets must be taken of each tree, and from ten to fifteen trees are taken each day, it would be utterly impossible to handle the volume of material without a hugh supply of blotters and papers—to say nothing of the labor involved. The tropical countries do not permit a white man to perform a great deal of active labor over a long period and any means for making the tasks easier is welcomed.

Conditions vary so much with different natives and tribes that one must adopt special tactics for each country in which one is working. The West Indian negro is about the most consistent worker in the Carribbean, but he has to be driven and bullied at times. The Spanish peon is lazy and indifferent and treacherous, but when once his enthusiasm is aroused he will do twice the work of a black man in half the time. He harbors a grudge for years, where the African will forget it over night.

The Panamanian Indians do not fraternize with other natives nor do they work for the whites—except the Chiriqui nation on the Pacific watershed who have been in contact with the civilized people for hundreds of years. Those indians living in the mountains are still savage and use the poisoned dart to get their meat. The San Blas tribes on the low coastal fringe from the Canal to the Colombian border are pacific in their attitude and friendly when proper overtures are made by the white men. The Darien tribes of the mountains are surly and beligerent, especially if they think the white man is going to steal some of their natural resources. It is quite similar to the situation existing when North America was settled by the Pilgrims. The Indians have a great respect for their women and will not tolerate any promiscuous relations on the part of outsiders, black or white. They are monogomous for the most part although the families often live in large clans under one hugh thatched house which is divided into several partitions. They sleep in hammocks made from fiber.

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FACTORS INFLUENCING INDIVIDUAL CAPACITY

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such important fashion for pedagogical application in school work with normal and even super-normal children.

A great deal has been written upon the peculiar nature of the uninhibited mental life of children and young people who have suffered from an attack of encephalitis lethargica. The publications of Jelliffe with his extensive references to the literature on the subject are to be commended. The following case, with its amusing as well as tragic details, can be offered in brief as another demonstration of reciprocal relationships between mental capacities and personality characteristics as related to the output of the individual, that is, to behavior in a wide sense. It offers, too, a splendid illustration of the fact that here we have a disease interfering with personality but not at all with intelligence.

A lad, 10½ years old, was brought to us for study because of erratic behavior which showed itself in temper displays on slight provocation, running away when scolded, inability to remain in school throughout the day's session, undue eagerness for attention, etc. In a number of interviews we found him very friendly, responsive, and intelligent; he showed initiative, energy, and good powers of common-sense observation. Even in the testing periods which had to be made fairly brief, he worked with deliberation and much interest. His I. Q. was 135, and in tests of all sorts he showed uniformly good ability. Though he was in the 4th grade at the time, his performance in school achievement tests was equal to the 8th grade norm. Indeed, he readily comprehended a high school passage.

We elicited the history that up to 15 months earlier this boy had been very quiet, manly, and most attractive in all ways. He had developed well physically, with no neurological signs whatsoever. Then he had suffered of an illness of no particular severity, but it was noted that for a brief period thereafter his eyes seemed to be crossed, and he slept most of the time for about 3 weeks. Following this his personality seemed to be changed in ways which we have mentioned. Our observation of this boy during 5 years corroborates our experience with other cases of this kind that we have studied and is also corroborated by many observations made in this country and abroad, namely, that so far no effective treatment, educational, disciplinary, or medical has been devised. There seem to be plenty of evidences that a sub-acute encephalitic process continues, and there is little hope for this disease which in some way affects the brain cells, wherein lie the powers of inhibition and self-control, until the nature of the disease and its specific remedy is found.

This boy has remained active, charming, and intelligent, but it is certainly true that he is beginning to show softenings of the lines of facial expression that may well be the forerunners of the well known Parkinsonian syndrome that develops in some of these cases. His career during the past 5 years has been chequered. His treatment at home and in splendid foster homes and in a correctional institution, to which he was sent with the idea that perhaps mild discipline would prove helpful, has embodied all the devices that one's ingenuity could offer. His response has not been marked by recalcitrancy as a rule except at the idea of being forced into a steady regime of any kind. His intelligence enables him, as in other cases we have studied, to estimate the situation fairly, and he makes the point that he simply cannot stand the regularities of school life, of institutional confinement, of a steady regime of any kind. Once, when it was suggested that like a well made automobile his good body and fine mind afforded a good machine, his instant response was, "But you need somebody to steer it well, don't you?" His ability to get pleasure out of life by exercising his shrewd native intelligence is shown by the fact that at a period when he evaded school for some time in his home district by getting a school transfer through alleging that his family was to move to another district, he made great friends of the police in the neighboring station house. He told them of an alleged uncle who was a manufacturer of sporting goods. In the meantime, he was playing about a school in another district where the boys had organized a class baseball team. When they bought new outfits, he purloined a large share of these and took them to his friends, the policemen, and presented them as gifts from his uncle for the policemen's own children. When, after much troublesome behavior in his neighborhood, he was sent to a correctional institution, he speedily ran away time and again until it came about that the parole officer in his city district, whose duty it was to look for runaway boys, catching a glimpse of this youngster, himself turned his back and ran away.

Through this exceedingly fine ability, he has picked up much information about a variety of subjects, but he remains an utter school failure, and because of uncontrolled delinquencies a social menace.

A girl whom we have known for 10 years was first seen when she was 15 years old—already an extremely difficult problem on account of excessive amount of sex immorality. Her I. Q. was 100 but her performance on the age-level and on other tests was decidedly irregular. She was only in the 6th grade, doing fair work, but there was much complaint of her restlessness and poor behavior. Thoroughly tested again when she was 17 years old, she had then practically the same I. Q., 97, and showed once more a good many irregularities and poor motor control.

At 8 years of age this girl had had a severe attack of chorea, and prior to that she had had many other diseases. Earlier she showed symptoms enough to be called psychoneurotic. Later she outgrew these and could then be termed a divergent personality, egocentric and unstable, of the type that is sometimes called a psychopathic personality. The personality changes modified by disease were to be seen in the peculiarities of the test performance, although not in the least evidenced by any rating according to I. Q. or stating that she was of average or better than average mental age.

It may be that we shall have to regard chorea as often being a continuing smouldering disease, affecting the brain cortex in some cases, just as we have been forced to regard encephalitis lethargica as being a continuing pathological state. Only the prognosis is vastly better, as may be shown in this case. On account of her boldly exhibited sexual tendencies, this girl had to be placed in an institution for 2 years. Following that and up to the present she has been given skilled personal attention and guidance. There has been a gradual increase of stability. By the time she was 20 years old she had stabilized much. However, the interesting part of this is that the girl herself had come to realize her own instabilities and had come to look at them in an objective way. When she found herself acting too impulsively, she frequently came to her mentor to be steadied. As a young married woman, she is able to maintain a happy household.

Personality Assets and Liabilities.

Of course this paper touches only on a few of the many possible and exceedingly varied illustrations of the factors that

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News of the Yale Aeronautical Society

Some of the Recent Activities of Yale's Progressive Aeronautical Society—The Intercollegiate Aviation Conference.

By D. F. MacEachern, 1930S.

THE movement started at Yale a year ago for the establishment of an association to connect the flying clubs in colleges was carried on this year at Columbus under the supervision of the Ohio State Aeronautical Society. When Tom Pearce, who was in charge out there, heard that Warner of N. Y. U. and Morris of Yale were going to fly out, he immediately announced to the press that there was to be an intercollegiate air derby. The idea was good, but the University authorities here did not feel that they could take the responsibility connected with it, so it became an individual race rather than an intercollegiate one. Just to prove that it was an entirely friendly competition, the Yale Aeronautical delegates landed in an emergency field when they sighted the N. Y. U. plane there, and when they found that it was out of gas, contributed some out of their tank enabling the N. Y. U. plane to proceed to Utica and refuel. One can hardly imagine a Harvard-Yale track meet in which a Yale runner would stop while the Harvard man recovered a lost shoe. It is our opinion that flying clubs can bring colleges closer together in this way than any other sport could.

Another high-light in the trip was getting lost (according to the press) over Erie, Pennsylvania. The Yale flyers set in at the City Airport in Erie to refuel and the N. Y. U. contingent proceeded on their course. By the time that the Waco, the plane flown by Morris, had reached Cleveland it was four o'clock and dusk was beginning to obscure the ground so it was decided that the safest thing to do would be to land at Cleveland and take the train to Columbus, rather than attempting to make Columbus by plane. When the Yale men arrived in Columbus, they went to bed immediately without telling anyone that they were around. The newspapers, having received no word as to their whereabouts, decided that they were lost and thought that they had made a big scoop. As it turned out, it was lucky that the Yale men did not try to make Columbus by air, because when the N. Y. U. plane arrived, darkness had obscured the field and there was almost a serious accident when the plane barely missed a row of stakes that had been placed around a newly-seeded plot of ground. The airport authorities did not turn on the flood lights because the air port was not completed and they did not want to give the pilot a false impression by turning on the lights.

At the meeting of the executive committee of the Intercollegiate Aeronautical Association, it was decided to fix the dues at a dollar and a half for non-flying members and six dollars for flying members, also to issue a monthly bulletin which is to contain a report by each member society as to its activities, and to take up the insurance proposition of the National Aeronautics Association for consideration. It was originally intended that a manager should be selected from those members of the Association who had just graduated from college, but it was finally decided that a man one year out would hardly be in a position to give his time in exchange for the meager pay which the Association could afford, so it was decided to elect an undergraduate to the position. C. L. Morris, 1932S, was selected to fill that job as well as being the chairman of the executive committee.

The New Airport.

Last year there was only one port available for the use of the society. That was the airport at Stratford, 16 miles away. The only convenient way of getting there was by automobile, and for most undergraduates, that was impossible. There was, of course, the airport at Hartford, but that was 40 miles away. The result was that the boys had to spend much more time going and coming than they could spend at the airport. This year things were much more favorable when we came back to school. There was the airport under construction on the Milford turnpike, named after Hiram Bingham. There was another out on Dixwell Avenue under construction, on the site of the old circus grounds, and there was the field at West Haven, the H. and H. field. After carefully looking over the three of them, considering first of all, the size, condition, and approaches of the fields, then the convenience of transportation, we finally selected the H. and H. field for our training.

We have had no cause to regret our choice. The field is licensed by the state of Connecticut for instruction and passenger work. There are two transport pilots employed, one of whom had experience during the war in France, and the other of whom has been flying since 1923. They are both young, likeable chaps, and give a feeling of comeradrie that we were never able to establish as well before. They have a licensed mechanic who is also a designer and therefore in a position to tell the students much about plane design that would be difficult to learn afterwards. They are going to furnish an office for us down there in the hangar, so that we may have more of a feeling of unity than we have had in the past.

There are a number of types of planes to select from there. Ordinarily a Fleet training plane is used for instruction, but, at the student's option, a Waco OX-5 or a Bird OX-5, may be used. For advanced training and cross-country work there are a Robin-Challenger and a Whirlwind-Travel Air. In this way the embryo pilot is able to get experience on radial or water cooled motors, and in cabin or closed planes.

The whole arrangement has worked out very successfully, but what we appreciate most, perhaps, is the fact that the airport can be reached by trolley in fifteen minutes, which makes it even possible for a man to get his flying in between classes if he is in Sheff. where there are so many afternoon classes.

Ground School Classes.

After deciding to use the H. and H. airport, we asked the people down there if they could run a ground school for us. They were only too glad to help us out, and Jack Lenox, veteran pilot, and Johnny Crane, designer and mechanic of no mean ability, offered to come up here to talk to us. The meetings

are held every other Wednesday evening in the Mason Laboratory. The topics discussed are:—nomenclature, theory of flight, navigation, airplane engines, aerodynamics, and kindred subjects. The course is designed primarily for the man who is going to fly his own plane and who will need to know the fundamentals of its construction so that he can more efficiently care for it. For those who intend to go into the engineering end of aviation it can be no more than an introduction, but for the man who is going to use a plane in his business it is very valuable.

As an addition to the regular course, the members of the society have been extended an invitation to visit the airport at any time and watch the work on engines, or, when occasion permits, on plane repairs. This is the practical end of the course that we have been trying to get for some time, but have never accomplished until now. The interest shown in the course in general has been very encouraging, but we feel that many more people should avail themselves of this opportunity.

The officers for this year have been:—D. F. MacEachern, 1930S, President; C. L. Morris, 1932S, Vice-President; W. Hoffman, 1932, Secretary; and D. Moore, 1931S, Treasurer.

APES AS INSTRUMENTS OF HUMAN PROGRESS

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Another member of the staff, Professor Harold C. Bingham, is at present engaged in field study of the mountain gorilla in the Parc National Albert of the Belgian Congo. This undertaking was made possible by the coöperation of the Belgian Government and of the Carnegie Institution of Washington.

The third type of establishment has recently been financed by the Rockefeller Foundation, and Yale thus enabled to purchase a tract of land near Jacksonville, Florida, for subtropical anthropoid experiment station. The plans for this laboratory are well advanced and it is hoped that the station may be ready for use not later than the summer of 1930. In this subtropical laboratory one or more types of great ape will be bred and observed under rigidly controlled conditions. Initially at least attention will be given to studies of the psychobiology and physiology of reproduction, structural and behavioral growth and development, heredity and environmental influence. In addition, this establishment as practicable will supply apes of known ancestry and life history for use in the New Haven laboratories of comparative psychobiology.

This description of our tripartite organization and program inevitably suggests the picture of a three-ring anthropoid circus, but unlike the multiple-ring circus the establishments in point are mutually dependent and their activities are to be closely integrated. It is appropriate to think of the New Haven laboratories as concerned primarily with intensive experimental study of certain biological problems and with the ordering, assimilation, and coördination of results of anthropoid research. From field stations in Africa and Malaysia there will come from time to time, as expeditions return and make report, new facts concerning the psychobiology and ecology of the free, wild anthropoid ape. It is expected that such information will supplement, correct, or verify what has accumulated during the centuries. Finally, the subtropical breeding station will supply animals of known age and history and also will offer uniquely favorable opportunities for the continuous study of individuals from the hour of conception to maturity.

In this plan and program of research the ape is a means to certain objectives which are our approximate ends. We are concerned primarily with the solution of problems and the extension of knowledge of behavior, experience, and their relations among themselves and to organic structure. That we happen to be using chimpanzees, gorillas, or orang-outans, instead of men, mice, or bacteria, is merely incidental. By and through patient and skillful use of types of primate which most closely of all living creatures resemble us in structure and behavior, we even dare to hope that approach may be discovered to the problem of consciousness. How disappointing it would be to mankind and how serious a blow to his pride were the chimpanzee to become the instrument in a revolutionary discovery concerning mind and body.

MECHANICAL ENGINEERING

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gineers for some time. Each subject is approached with a treatment of underlying principles as they are now understood, and in some cases their treatment goes beyond what may be desired for undergraduate study.

This book is the most widely used textbook on this subject published in this country, being considered the standard text in most engineering colleges. It has been adopted at Yale by Mr. H. W. Best for use in a course on Airplane Engines. Professor Lichty is also using it as a reference book in a graduate course on Internal Combustion Engines.

CHEMISTRY

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Dr. Oskar Baudisch previously connected with Yale is doing research work here on a Chemical Foundation Fellowship Tuberculosis Research.

Dr. Charles L. Reese (Dupont) spoke here on October 30, 1929 on the Relation of Research to Industry.

Professor Hans Clarke of Columbia University gave a lecture on November 13 on the Influence of Chemistry on Medicine.

The growth of Chemical Engineering has necessitated the installation of 30 new laboratory desks for control work in the Chemical Engineering Laboratory.

Professor A. J. Hill was recently elected National Secretary of the Organic Chemistry Division of the American Chemical Society.

Professor Harry Curtis was recently appointed vice-chairman of the Division of Chemistry and Chemical Technology of the National Research Council.

Dr. G. R. Burns published a paper entitled, "Photochemical Decomposition of Lactic Acid", in the October issue of the Journal of the American Chemical Society. This paper is based on an investigation, carried on during the past three years, of the decomposition of lactic acid under the influence of extreme ultraviolet radiation.

Professor Stuart R. Brinkley was the delegate representing the American Chemical Society at the inauguration of Dr. Clarence Augustus Barbour, President of Brown University, on October 17 and 18.

Professor Worth H. Rodebush, of the University of Illinois addressed the New Haven Section of the American Chemical Society at the November meeting in the Sterling Chemistry Laboratory on the subject "The Significance of the New Quantum Mechanics in Chemistry."

The November issue of the Journal of Chemical Education contains an article by Professor Stuart R. Binkley, entitled, Typical Oxidation—Reduction Reactions in General Chemistry." This paper was presented before the Symposium on "Lecture Experimentation," Division of Chemical Education, at the Columbus Meeting of the American Chemical Society in May.

THE NATIONAL ACADEMY OF SCIENCES

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his address at the dedication of the building, well said: One of the most important possibilities for service of the National Academy of Sciences in the future lies in its opportunity for inspiring the people of America to insistence upon having the truth, and nothing but the truth, regarding everything that touches our life as a nation. It is always to be borne in mind that while the peculiar relation of the Academy to the Government of the United States may concern the conduct of specific researches, the example of dignified emphasis upon the truth as reached by correct thinking in every department of research and in its practical applications, may be a contribution of inestimable value to the whole people. It is for this purpose that the Government sets its stamp of approval upon this effort, and joins in dedicating this building to the betterment of the human race by achieving a clearer knowledge of the truth.

Perhaps the words of Aristotle, carved in the marble across the main facade of the building, epitomizes the spirit of the National Academy and the Research Council: The search for Truth is in one way hard and in another easy. For it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of Nature, and from all the facts assembled here arises a certain grandeur.

FACTORS INFLUENCING INDIVIDUAL CAPACITY

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condition personality and so influence immensely the individual in the utilization of his abilities. A complete picture must stress assets as well as liabilities. Among the assets would be included health, good appearance, energy, and a good physique (although a super-abundance of growth or strength sometimes work in the opposite way), fine ego-ideals, and lack of repressions; in some cases an asset is the "golden complex", namely, the struggle against an inferiority situation, and so on. Among the liabilities we would list just such factors as we have discovered in our cases—the effects of trauma, physical and mental, of diseases of the nervous system, of endocrine imbalance, of chronic infections and irritating physical conditions, depleting physical habits, unresolved mental conflicts, repressions, and other subtle disturbances.

And so it becomes obvious that there are very many elements that go to decide to what extent an individual gets satisfactions out of his capacities, or how he uses them in meeting life's tasks—a fact that is true for all of us, not only those who come for study as present problems.

And when it comes to consideration of actual mental capacities, the value of a thorough psychological testing is in the ascertainment of what powers the individual has when working at his best. Testing is requisite for the discovery of latent or unsuspected abilities. We have even discerned in some instances that the non-utilization of latent abilities was the source of personality difficulty.

All this discussion of reciprocal relationships seems to us very simple and obvious. We have decided to make it our theme, however, because we have found, both here and abroad, that when individuals are presented for either psychological or psychiatric examination, very frequently many factors so interrelated are disregarded. Some elements entering into the picture either are not at all studied, or if studied, they are not interpreted each in the light of the other. So it comes that more emphasis upon the values accruing from better rounded studies is certainly not amiss.

OUR CONTRIBUTORS

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¶ *Professor Robert Mearns Yerkes, who writes on Apes as Instruments of Human Progress, received his A.B. degree from Ursinus College in 1897 and from Harvard in 1898, where he was given his A.M. in 1899 and his Ph.D. in 1920. He was honored with an LL.D. by Ursinus in 1923 and with a D.Sc. by Wesleyan in 1923. From 1902 to 1907 he was instructor in Comparative Psychology at Harvard, becoming Assistant Professor in 1908. He was also psychologist of the Boston Psychopathic Hospital from 1913 to 1917. He was called to Yale in 1924 as Professor of Psychology in the Institute of Psychology. On the first of July, 1929, he was appointed Professor of Psychobiology in the newly-founded Institute of Human Relations.*

¶ *Professor H. L. Seward, who writes in this issue on Marine Engineering and Design, was graduated from Yale in the class of 1906 S. after which he taught and did graduate work. In 1908 he received his M.E. degree. For some time he was in charge of the Mason Laboratory. He was largely responsible for the work of the U. S. Navy Engineering School at Hoboken. In the summer he serves as Consulting Engineer and does special work for the U. S. Shipping Board of which he has been a member of the Fuel Conservation Committee since 1924. Recently he was appointed Assistant to the President of the American Bureau of Shipping. He has been Professor of Mechanical Engineering since 1928*

HOW SCIENCE DISCOVERS RARE TREES

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The West African natives are the product of isolation for centuries and have suffered greatly in consequence. They are the "children of the world" today in point of evolution and all lines of development. The confusion of language and dialect is a bar to successful intertribal intercourse, and so far the efforts on the part of white educators to solve this vital question have not been successful. Pidgin English is used throughout the West Coast by white traders and planters. The best way to make a native understand is to perform the task and let him learn by imitation. He is as quick as a monkey in repeating actions and gestures. The notes concerning the trees and plants, which are so essential in making a complete survey of the flora, must either be pieced together from fragmentary native information gleaned at various times and from different sources, or they can be obtained through the aid of a native clerk who can translate the information into English and record it in some fashion.

In the Central American countries the information will be in English if given by a West Indian, or in Spanish if taken from a peon. When indians are used in the work their information is translated into the Spanish or English by a native who can converse with them. There is a similarity between all the tribal indian dialects whose people are remotely related in the past, but as they have degenerated and become segregated, their language has been corrupted according to their new environment.

After the material has been gathered and dried and carefully wrapped to keep it from getting mouldy it is packed and transported to the coast and sent up to New Haven where it is sorted and sent out to systematic botanists for proper and accurate identification. The Central and South American flora

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PROGRESS IN AUTOMATIC TRAIN CONTROL

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actuating the engineer's brake valve itself. Suitable provision must also be made for accomplishing the release of the brakes after the desired result has been obtained. In addition to these essential elements, a further refinement may be provided whereby under certain conditions the speed of the train may be controlled within predetermined limits according to the position of the train with respect to the danger zone; forestalling devices provided to permit the engineer to acknowledge restrictive signal indications and proceed with his train under control within predetermined limitations; indicators, cab signals, etc., to further inform and check the engineer in his interpretation of track conditions and signal indications, and the response of the train thereto. Considerable importance was placed at first upon the provision of a device to automatically close the locomotive throttle at the time the brake application is initiated but an analysis of operating conditions and a study of service results failed to disclose a sufficient need for a device of this kind, considering the complications involved and the uncertainties of service.

The most recent development in automatic train control apparatus has been in the adaptation of the cab signal system in combinations with an automatic train stop, under continuous track circuit control, the mechanism on the locomotive being actuated by alternately opening and closing the track current circuit. The number of interruptions per minute in the track circuit determines which of the possible four signal indications will be displayed in the cab of the locomotive, depending upon the conditions of the track in advance. The system is adaptable to electrified roads, operating on either A.C. or D.C. current and to any of the well known types of steam road wayside signalling equipment. The automatic stop feature of this equipment causes a predetermined "service" application of the brakes, if, for any reason, the engineman does not make the proper response to the signal indication. He retains manual control of the brakes at all times except in case of failure to acknowledge a restrictive signal indication in which case the brakes apply and cannot be released from the cab. On the other hand, a change in the track conditions from a restrictive to a higher speed permissive aspect will be automatically and visually indicated by the cab signal, permitting the engineman to take immediate advantage of the opportunity to resume speed. Its chief function is to inform the engineman who is skilled and alert so as to enable him to take immediate and maximum possible advantage of the conditions of the track ahead, in spite of the weather, passing trains or other conditions obscuring his vision, and to act automatically so as to insure the safety of the train, should the engineman for any reason fail to act in accordance with any restricting conditions ahead.

Speed control features are secured by the installation of a centrifugal governor on the engine driven by suitable gearing from a locomotive wheel or axle. Means are thereby provided for reflecting the speed of the train in a mechanism on the locomotive which can be utilized to control electric circuits or air valves, which are arranged so as to have no effect so long as the train speed is within the predetermined amount, corresponding to its position with respect to the danger zone, but which will automatically cause a suitable brake application if the predetermined speed is exceeded. By this means it is possible to secure automatic control to whatever degree of refinement circumstances warrant.

Consider for a moment the operating problems involved in the proposal to substitute for the engineer an automatic device. Let us assume that 100% perfection is reached when the apparatus functions as would a skilled engineer when in full possession of all necessary information. Even with the best of judgment and skill, the most experienced engineer cannot always properly evaluate the effect of speed, length of train, condition of draw bars, brakes, train loading, track and weather conditions and so on. An automatic system can provide for certain conditions and for certain external variations in these conditions, but it is evident at once that it must be installed to function in accordance with some selected combination of these variable conditions and cannot thereafter automatically adjust itself except in a very restricted manner, and with reference to only a few of the conditions mentioned.

Consequently, the automatic train control apparatus does not, nor cannot be expected to, supplant the judgment of a skilled and alert engineer in making the most of all possibilities in the direction of maximum speed consistent with minimum risk.

The extent to which automatic train control has been applied indicates its rapidly growing importance as a factor in present and future transportation developments. About 80 different railroads in this country have some or all of their trains operating under some form of automatic train control over a total of more than 20,000 miles of track, extending into 35 states and requiring nearly 10,000 locomotives. About 15% of the locomotives and 7% of the track mileage of the United States are now equipped for automatic train control. While certain classes of accidents have undoubtedly been prevented, the saving in number of stops and slow-downs eliminated, and more uniform movement of traffic accomplished thereby, are by far the most significant results. With the information and the safeguards provided the engineer, some of the greatest uncertainties and hazards in railroad operation, especially under bad weather and line conditions, have been very considerably reduced, and this is an advantage which is continuously being credited to the system.

The savings thereby secured can only be estimated. No exact comparison can be drawn to show the degree to which this offsets the expenses of installation and maintenance, and these are considerable. Taking into account all of the readjustments of signals, of engine equipment, car apparatus, etc., it has been estimated that train control has cost the railroads about $26,000,000, not including the cost of maintenance.

Mr. R. H. Aishton, Chairman of the Executive Committee, Association of Railway Executives, at a hearing before the Interstate Commerce Commission in the spring of 1928, stated that during the previous eight years the railroads of the United States had expended $323,701,000 of capital for safety purposes, of which all but $22,395,000 had been expended voluntarily. These expenditures covered automatic and other signals, highway grade separations and extensions of automatic train control installations beyond those required by the two orders of the Commission.

Comparisons and total maintenance costs are extremely difficult to compile with any approach to accuracy on account of rapid developments and variations in types, methods or accounting, etc., but estimates have been made, varying from $14 per month per engine to as high as $100.

Competent observers, and among them some of the most able railroad operating officials, are convinced that the automatic train control system will develop into one of the most effective means for increasing the safety and speed of traffic by rail.

On November 28, 1928, the Interstate Commerce Commission announced its decision that additional installations of automatic block signals and automatic train control devices would not be required by order, but pointed to the necessity for continued diligence in adequately providing against accidents due to grade crossings and other sources of delay and danger to traffic. It further admonished the railroads to continue making necessary studies and tests to bring about a standardization of the designs and methods of installations of train stop and train control devices. It stressed the introduction of the cab signal as one of the most important and significant developments in this connection. Action will undoubtedly be taken by the railroads themselves to extend the application of cab signalling, of automatic stop systems, or of complete speed control systems, according to the operating and physical requirements of their lines.

The evident purpose of the Commission is thus being accomplished. Automatic train control has been developed to a state of practical operating efficiency on a large scale.

Installations of automatic block signals are being made extensively, which means still further economics in operation and increased safety. The increased protection to traffic is having a reflex influence in other operating practice relating to traffic control. For example, with the full protection afforded by automatic block signals and train control, including cab signals, the requirements for protecting the rear ends of trains by flagmen are very greatly reduced, which is a direct saving in time and reduction in hazard.

PERSONALITIES

(Continued from page 27)

Physical Review in 1913 and at present is an associate editor of the Journal of the Franklin Institute. He holds degrees from Minnesota, Cambridge and Yale. At Yale he is a member of the Aurelian Honor Society and the Berzelius Society.

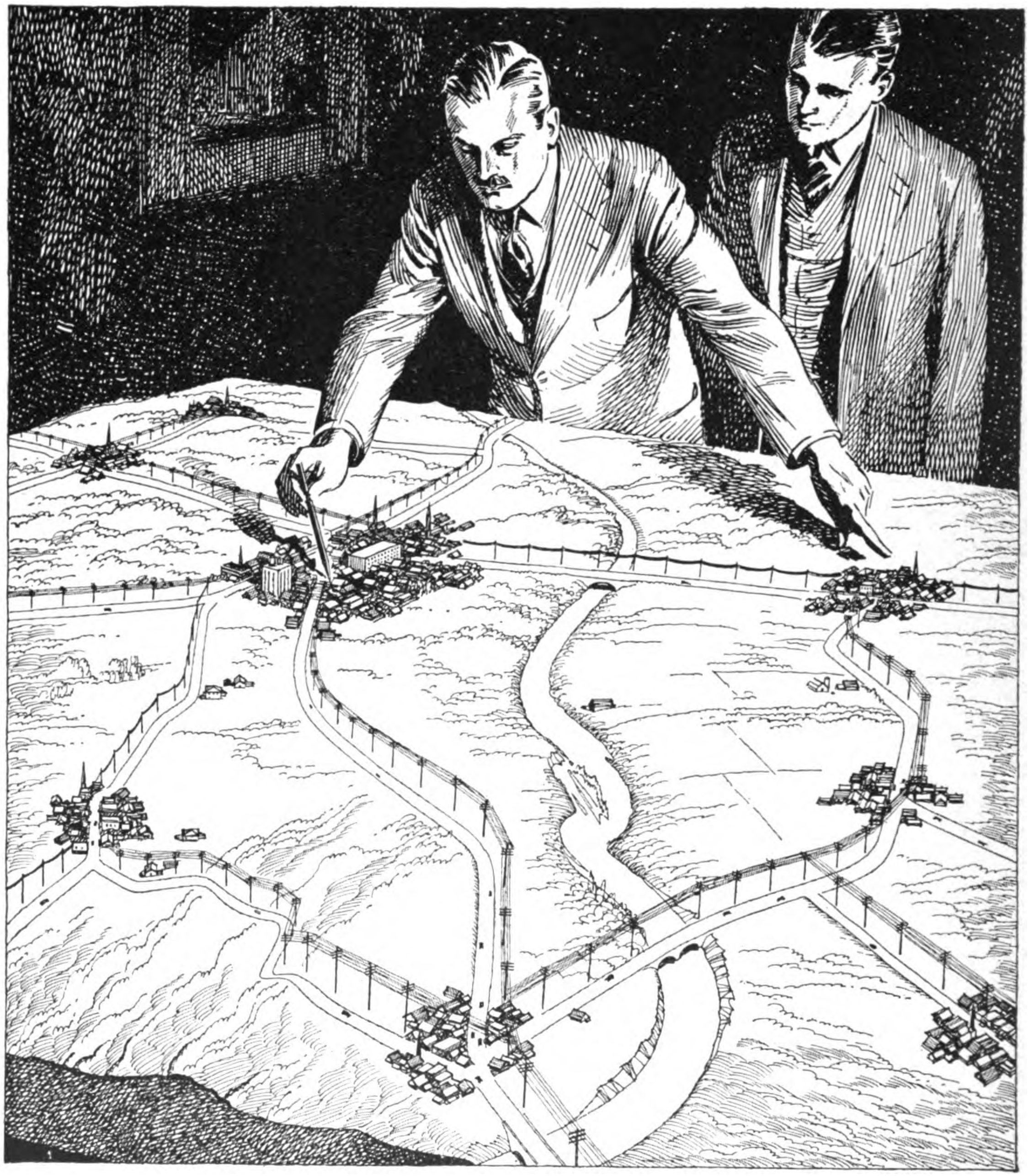
During his connection with the University of Minnesota he was also an associate professor of physics, 1906-8, and held the full professorial rank, 1908-15. During the year 1912-13 he was acting dean of the graduate school. The only sabbatical year he has had was in 1914-15 which he chose to spend in research in Cambridge working again in the Cavendish Laboratory with his former teacher Sir J. J. Thomson.

When Professor Charles S. Hastings retired in 1915 as the professor of physics in the Sheffield Scientific School, Professor Zeleny received a call from Yale to fill the place made vacant which he accepted. Physics at Yale was housed as one department in the Sloane Laboratory from the time this building was finished in 1912—a harmony of Sheff and College, several years before the University reorganization which required other departments to entertain similar charity. Professor H. A. Bumstead was the professor of physics in Yale College and the director of the laboratory; Professor Zeleny, the professor of physics in the S. S. S. was the chairman of the department, a position he has filled to the present time and to the full satisfaction of the department. For several years after Professor Bumstead's death, he was also acting director of the laboratory.

During the period of the war, he was actively engaged as a member of the Committee on Submarine Detection and carried on experimental work both at New Haven and at the submarine base at New London. In this work he achieved success with aural, multiple unit submarine detectors as well as with magnetic detectors.

In 1905 he married Carolyn S. Rogers of Monroe City, Missouri, and is the proud father of two daughters, both of whom

(Continued on page 40)



Key Town selling
—a new telephone idea

PERSONALITIES

(Continued from page 37)

received college education, the younger being at present a senior at Vassar. He spends the greater part of his vacation in New Haven but generally goes to the mountains or to some wilderness for three or four weeks. He is interested in sports generally and used to be a splendid tennis player while he was a student and for many years after. He also paid some attention to hunting and fishing (ask Dean Jones for some stories) the two used to go together, and so keep your mind alert when you hear the stories of hunting and fishing in the wilds of Minnesota or Long Island. During the last few years he has been enjoying golf and although he started the game rather late in years yet he gives frequent drubbing to his opponents in Class B at the Country Club—in fact, the first year of his golfing he won a cup.

In his contact with students he likes open and frank dealing. It is his desire to have every student feel at ease in his classes and at liberty to consult with him about his work; officially he is the adviser of a great many students. He does require attention to work and has an exceptionally keen power to differentiate students who have natural difficulties with physics from those whose difficulties are due to "sliding along." He has much control over himself and is always pleasant even in a disagreement. Not long ago a New Haven business man remarked that he talked over the telephone with the most pleasing individual on the University exchange: and that it was the chairman of the physics department who was at the other end of the line. It must be true, when one of these hard pressing "go-getters" acknowledges it himself. His most endearing characteristic is his kindness of heart.

PATHOLOGY AT THE YALE MEDICAL SCHOOL

(Continued from page 12)

physiological processes. The studies conducted thus far have made it possible to obtain data concerning the relation between physiological effect and the effect of these radiations in ionizing gases. Also this procedure permits the investigation of the influence of different wave-lengths of radiations on physiological processes.

Neuropathology and Oral Pathology

During the past year two new activities have been added to the work of the division, namely, neuropathology and oral pathology. Neuropathology has been neglected to a great extent in the United States and for sometime a movement has been under way at Yale to develop this field with the result that now we have one of a few laboratories where neurological material is thoroughly studied. A noteworthy feature of this section is the fact that it is an integral part of the division of pathology, a condition which does not exist in most places where separate departments are usually established. However, there are many advantages in the arrangement stated above. The section on oral pathology has been established as a part of a plan to carry on investigations concerning the relation between systemic disease and conditions of the teeth. Ample space for the beginning of this work has been assigned and equipment has been installed to permit the work to proceed.

Another section that plays an important part in work of the division is the art studio which is located on the first floor of Lauder Hall. In this studio an artist is constantly at work drawing or painting specimens representing various diseased tissues, or making charts illustrating experimental data. We now have illustrations representing perhaps the largest collection anywhere. The value of these illustrations both for teaching as well as having permanent representation of lesions can not be overestimated. Closely associated with the work of the art studio there is a museum in which there are specimens of various diseased tissues contained in glass jars and always available for study. Also in the museum there are typewritten, bound and illustrated records of all necropsies for use in conjunction with the study of specimens.

Instruction in pathology is offered to students who have sufficient preliminary training to take advantage of the courses irrespective of whether or not they are students of medicine. In the first course, the principles of the subject are presented and this is followed by a course in which clinical-anatomical demonstrations are held. In this manner, pathology is presented from the point of view of its relation to clinical medicine. Advanced work is offered to individuals in accordance with their interests and previous accomplishments. The physical facilities for teaching consist of an auditorium which seats 150 persons, individual class rooms, each of which is restricted to 6 persons. In the museum there is a place for seminar meetings and then, as previously stated, one of the necropsy rooms is available for conferences and demonstrations.

In addition, to the facilities described above there are offices for administrative work and individual office and laboratory space for the members of the staff.

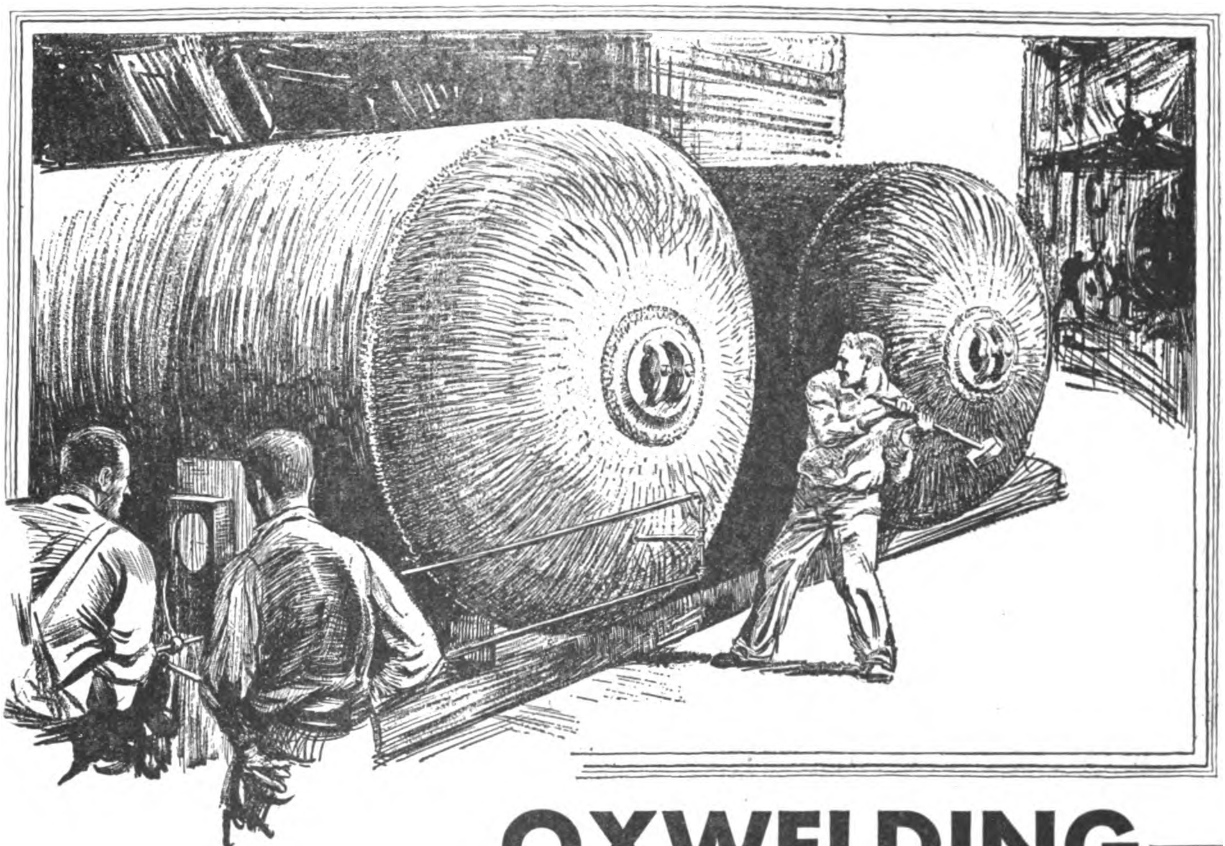
HOW SCIENCE DISCOVERS RARE TREES

(Continued from page 35)

is studied at the Smithsonian Institution, the Field Museum of Natural History, the New York Botanical Garden, and others, while the African material must be sent to Kew Gardens or to French and German herbariums. If frequently happens that the material sent in is without flowers and fruits and the sterile sample is difficult, if not impossible, to accurately classify. In this case, Professor Record and his assistants make a microscopic examination of the wood and generally find characters which enable the specimen to be allocated to a genus if not to the actual species.

Finally, after the woods have all been identified and filed, there is the report which must be written concerning them, for it is desirable to have information published from time to time concerning the forests of various regions, and especially so when some woods are found which show possible commercial qualities.

This is a brief survey of the work now being undertaken by the field staff of the Department of Tropical Forestry, and is supplemented by the voluntary contributions of many workers scattered all over the tropical world. Material is being received constantly for identification and study, and the Department is also interested in certain expeditions now working in East Africa and in the Peruvian Amazon. Duplicate material, both wood and botanical specimens, is available for exchange and in this way the collections are further enlarged.



OXWELDING—
PROVED BY TEST

Oxwelded pressure vessels constitute an outstanding example of the results which can be obtained through intelligent application of the oxy-acetylene process. Introduction of oxy-acetylene welding into the production of large pressure vessels has resulted in increased dependability, and noteworthy contributions to the knowledge of the best methods of design.

Never before has it been possible to test full size pressure vessels actually to destruction. With oxwelded construction, however, it has been possible to test each design until the plate itself failed and to correct any weaknesses discovered in design or materials. Test pressures of three times the working pressure are standard for oxwelded pressure vessels.

E. J. W. EGGER,
Resident Engineer,
Stevens Institute of Technology 1921
Three Letter Man
Football 3 years
Basketball 4 years
Baseball 3 years

W. S. WALKER
Development Engineer, Engineering Dept.
University of Wisconsin '26
Football 2 years
Wrestling 2 years
Honorary Society
Psi Upsilon Fraternity

From time to time the oxy-acetylene industry is in the market for technically trained men. It offers splendid opportunities for advancement.

One of a series of advertisements featuring College men serving this industry.

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UNION CARBIDE AND CARBON CORPORATION

30 East 42nd Street UCC New York, N. Y.

TENDENCIES IN MARINE ENGINEERING DESIGN

(Continued from page 18)

ates on steam at 250 pounds (gage) pressure and 250 degrees F., superheat, whereas the Modoc has 200 pounds and 90 degrees. All these are very real improvements and make for reduced operating costs. But the outstanding fact of all is that the *Pontchartrain* auxiliaries take only 25 per cent as much steam as those on the *Modoc*. Provision is made for the comfort of the crew, in case the vessel lies in port in the tropics, by the installation of a 100 KW Diesel auxiliary which will provide the necessary D.C. and A. C. power for port use while both boilers may be secured.

In the comparison of machinery of ships it is customary to consider fuel consumption for all purposes in pounds per shaft horsepower per hour referred to the propeller shaft. This figure for full operation is *Modoc* 1.195, *Pontchartrain* 0.823; for cruising speed *Modoc* 1.535, *Pontchartrain* 1.079.

Capital investment is always a matter of much concern to shipbuilders. For the new Coast Guard ships the total cost of machinery and boilers f.o.b factory was $175,000 per ship, which included all machinery except windlass, capstan, steering gear and quarters ventilating fans.

The statement can be made that the system used on these ships is not applicable to ships of large power. This is of course true, but one has only to stand in the engine room of one of our numerous freighters of the same horsepower, or study the performance records of this fleet, to realize that many applications of this system can be made with lower initial cost, less space occupied, and much lower operating costs. If auxiliary power requirements are in excess of 250 kilowatts it might be more advantageous to supply this power from an auxiliary turbine having at least five stages and exhausting against not more than one pound back pressure absolute. If the requirements for auxiliary power are below 250 kilowatts the difficulty is greater and the advantage of connecting up to the main plant is increased.

The greatest lesson learned from a study of most modern marine plants is that there is at last being developed a realization of the importance of using engineering methods of analysis in applying practices developed ashore and in the use of higher standards of operation not only to conserve the elusive B.t.u. but in all phases of the business of producing a ton-mile of marine transportation.

THE PROBLEM OF LIGHTING AND ILLUMINATION

(Continued from page 14)

so that the technical limitations now existing are no longer in his way.

The evolution of lighting from the period of mere illumination is under way. The influences of the past are giving way now that light, thanks to electricity, can be obtained in almost any quantity and is subject to control. Engineers are co-operating with designers in solving the problems of application, and in view of a great mass of evidence, we are beginning to realize that lighting as an art is a reality. We need now to consider light, not from the standpoint of foot-candles and working planes, but from that of its effect on the human being. What are the qualities of light that are distinguishable to us wherever we see? How do they affect our lives, and how can they be applied to our lighting problems?

In studying stage lighting, it is clear that the student must consider light in all its physical, physiological, and psychological characteristics besides that of its special application to a production. He must constantly remember that the audience must be led unconsciously to accept the illusion which he is helping to supply by means of light. While he must consider the instruments and control which he is to use, his plan or design involves the use of light from the standpoint of its distinguishable qualities—intensity, color, form, and movement—the whole gamut of our seeing faculties. He designs not only for visibility (which, by the way, does not increase directly with the amount of light), but for illusion, composition, and finally mood. He may take nature in its ever-changing aspects as a symbol to carry over the mood of a dramatic situation, or he may throw realism aside and compose with lighting for its sheer aesthetic appeal. Whatever he does, he designs with light as the sculptor does with clay, and he considers his instruments only as a means to an end. Comparatively speaking, his tools are crude, but he should never forget that tools do not make the artist. He must invariably alter his first conception to fit that which can be accomplished by means of the tools which he has at hand, and also in view of his knowledge of light. The principles involved in its study can be applied in other fields. In this connection it seems significant that a great university should find within its curriculum a subject which has so little scientific tradition, and which yet, by reason of its development there, should help in some measure to point the way for advancement in an important useful art—lighting.

PROFESSOR LICHTY REVISES INTERNAL COMBUSTION ENGINE BOOK

A new edition of Streeter's INTERNAL COMBUSTION ENGINES has been published this fall by McGraw-Hill Book Company. The new editions is a thorough revision, by Prof. L. C. Lichty of the Mechanical Engineering Department. Throughout the revision it has been kept in mind that the interest in internal combustion engines, at this time, lies chiefly in the liquid fuel engine of automotive and aircraft type.

Attention is called to the fact that the advance made in the past few years in the performance of internal combustion engines has not been due to the development of many new principles, but to a better understanding of those principles which have been known to many engineers for some time. Each subject is approached with a treatment of underlying principles as they are now understood, and in some cases this treatment goes beyond what might be desired for undergraduate study.

This book is the most widely used textbook on this subject published in this country, being considered the standard text in most engineering colleges. It has been adopted at Yale by Mr. H. W. Best for use in a course on Airplane Engines. Professor Lichty is also using it as a reference book in a graduate course on Internal Combustion Engines.

YALE REPRESENTED AT A. S. C. E. CONFERENCE

At a recent meeting of the American Society of Civil Engineers in Boston, a conference was held to consider the work of the student chapters of that Society. Representatives of eighteen chapters were present at this conference, including faculty sponsors and student members. Yale University Student Chapter was represented by A. Kaehrle, President; D. H. Battles, Secretary; and L. A. Ludwig. Professor J. C. Tracy, faculty sponsor for the Yale Chapter, opened the discussion on the "Duties of the Faculty Sponsor". Professor C. T. Bishop of the Department of Civil Engineering also attended the conference. Only one other chapter surpassed the Yale Chapter in the number of faculty and student members present.

MECHANICAL ENGINEERING

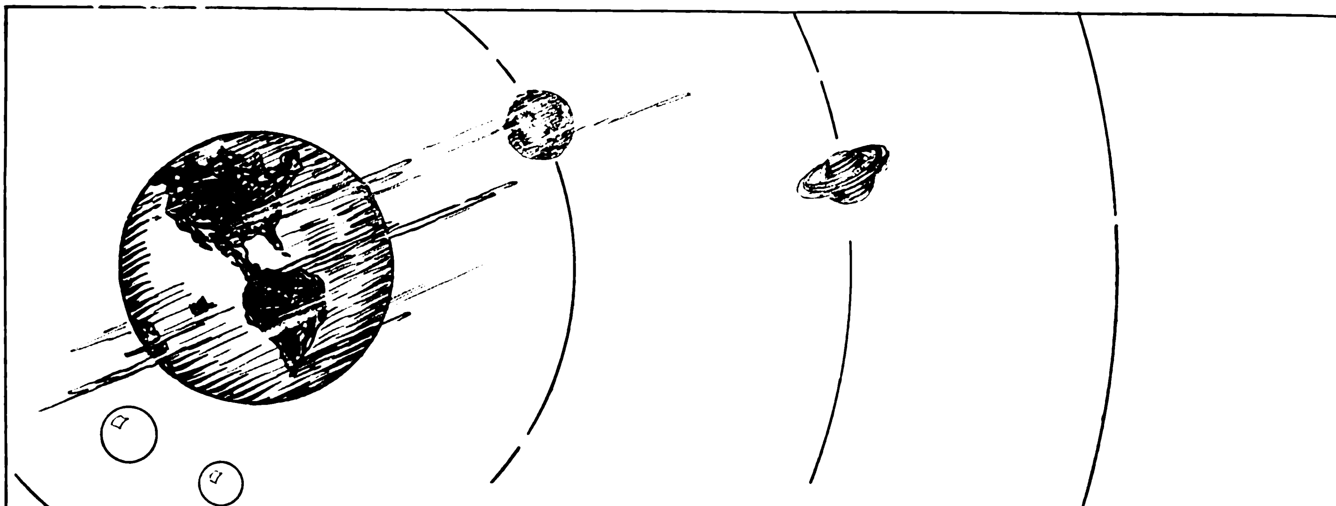
Herbert W. Best, M. I. T., '21, Instructor in Mechanical Engineering, attended the Saranac Lake Summer Meeting of the Society of Automotive Engineers and took part in the Mixture Distribution Conference.

Mr. Best reported how the mixture distribution in engine cylinders had been studied in Mason Laboratory by analysis of the exhaust gases.

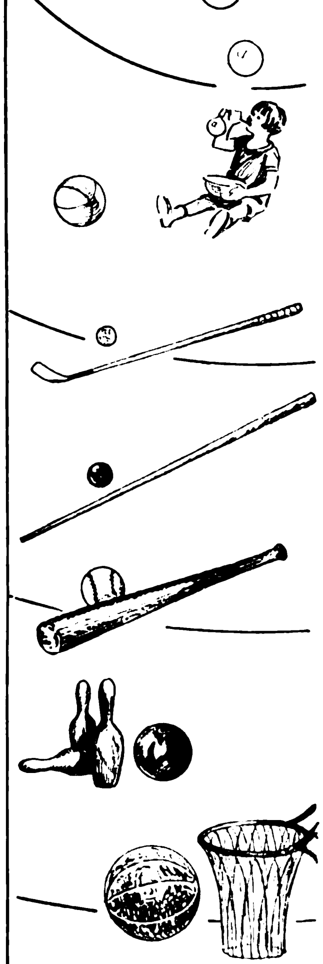
Professor Waters is continuing his work with the H. G. Thompson and Son Co., manufacturers of band and hack saws. The work involves miscellaneous problems in plant engineering and labor saving methods, and a general study of the efficiencies of different forms of metal-cutting saws, as determined by the cutting speed, pressure on the saw, form and size of tooth, and kind of lubricant used.

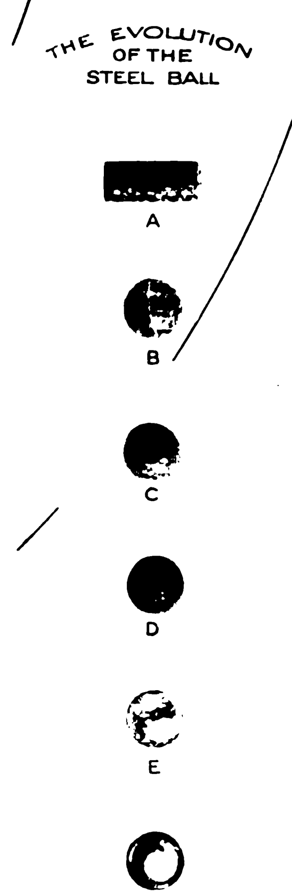
RESEARCH ASSOCIATE APPOINTED

Oskar Baudisch, who received his Ph.D. degree from Zurich University in Switzerland in 1904, has been appointed a Research Associate in Organic Chemistry at Yale University, with assignment to the Graduate School and with the rank of Associate Professor.



The Sphere is Nature's Favorite Form





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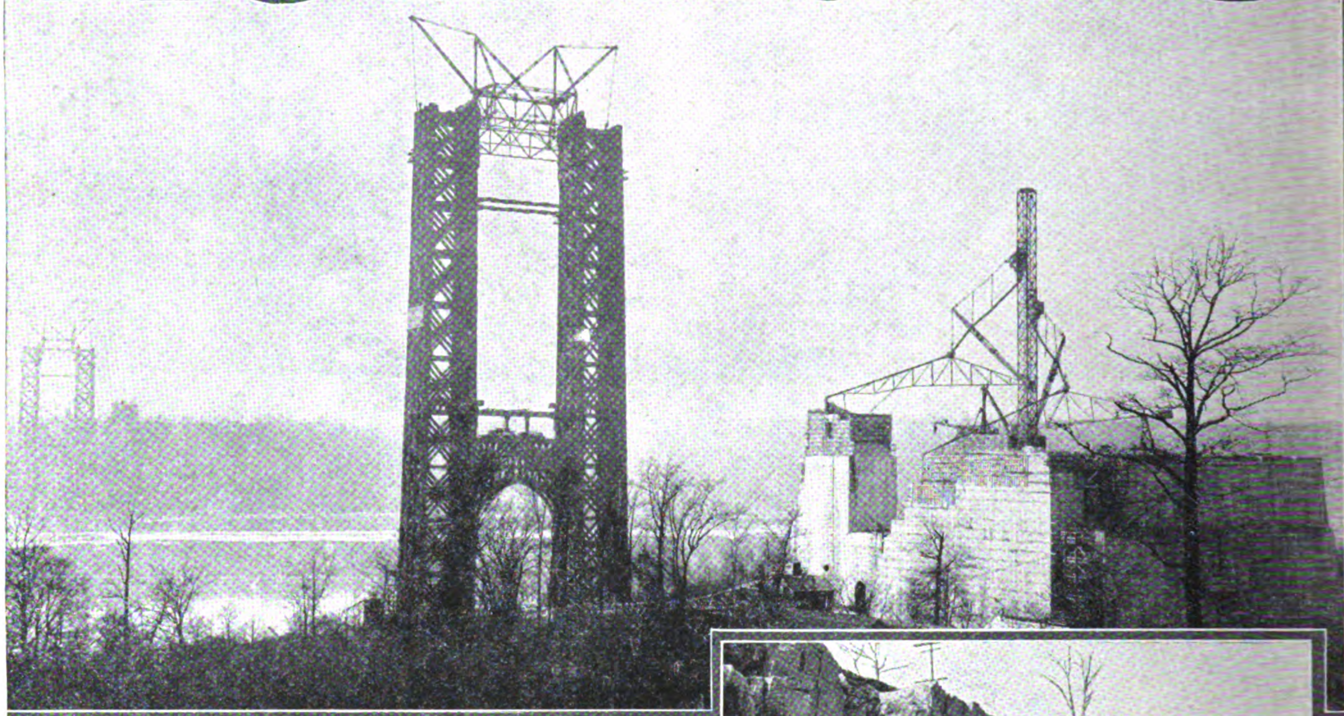


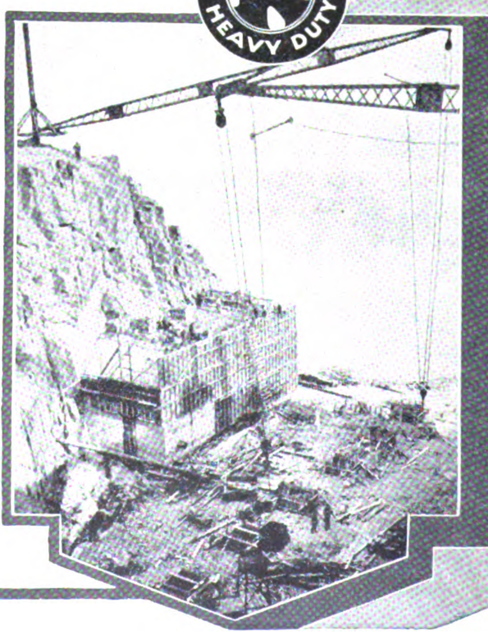
Anchorage for the Longest Suspension Span

A bridge with a main suspension span of 3500 feet, the longest in the world, will soon cross the Hudson river at New York. Suspension will be maintained by four 36 inch cables supported on steel towers 635 feet above the water level.

Abutments on the Fort Lee approach are shown in preparation in the views at the right. Two Koehring Heavy Duty products, a power shovel for the rock excavation and a paving mixer for turning out the Dominant Strength Concrete, were used in this work.

The massive New York anchorage above, 200 feet by 300 feet ground dimension and 125 feet in height, contains 110,000 cubic yards of quality controlled concrete mixed by two Koehring Heavy Duty Mixers.

Another identification of the Koehring re-mixing action with a structure built to endure!



The revised edition of "Concrete — Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, is now ready for distribution. To engineering students, faculty members and others interested we shall gladly send a copy on request.

KOEHRING COMPANY

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Manufacturers of

Pavers, Mixers—Gasoline Shovels, Cranes and Draglines

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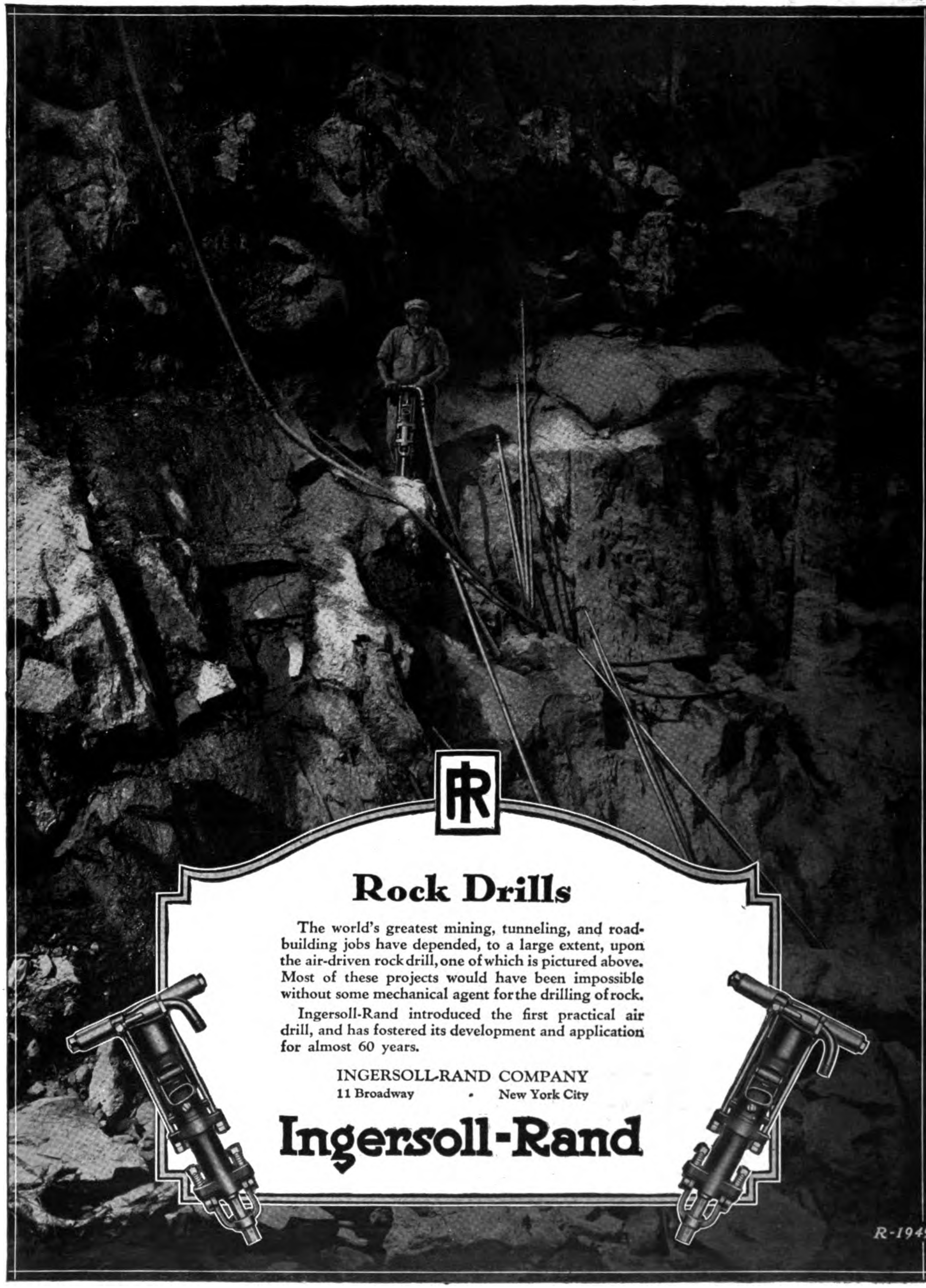
Rock Drills
The world's greatest mining, tunneling, and road-building jobs have depended, to a large extent, upon the air-driven rock drill, one of which is pictured above. Most of these projects would have been impossible without some mechanical agent for the drilling of rock.
Ingersoll-Rand introduced the first practical air drill, and has fostered its development and application for almost 60 years.
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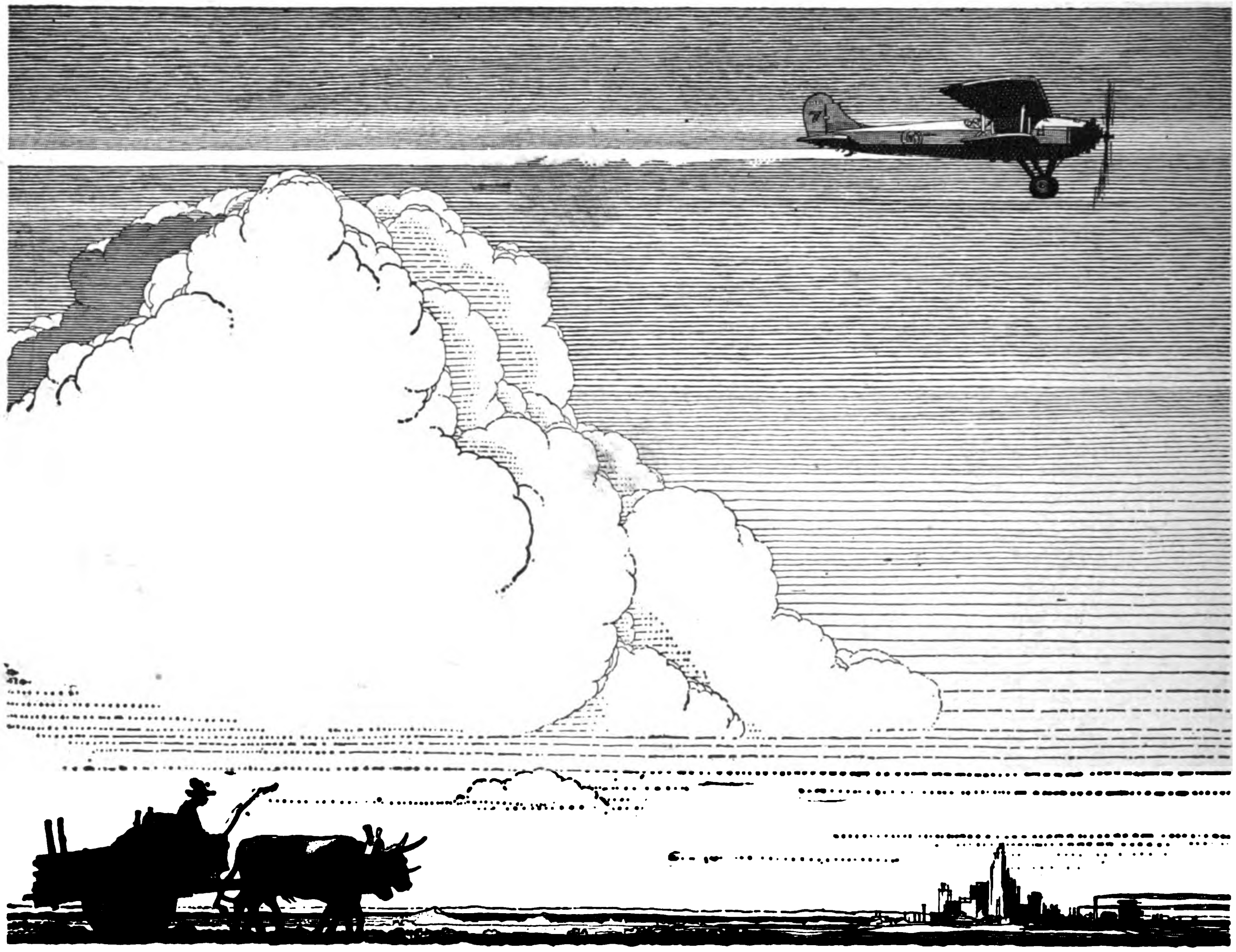

UP FROM THE OXCART

"Acceleration, rather than structural changes, is the key to an understanding of our recent economic developments."—From the report of President Hoover's Committee on Recent Economic Changes

YESTERDAY, the rumble, creak, and plod of cart and oxen. To-day and to-morrow the zoom of airplanes. Faster production. Faster consumption. Faster communication.

Significant of electricity's part in the modern speeding-up process is the fact that during the last seven years, consumption of electric power increased three and one-half times as fast as population.

General Electric and its subsidiaries have developed and built much of the larger apparatus that generates this power as well as the apparatus which utilizes it in industry and in the home.

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GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

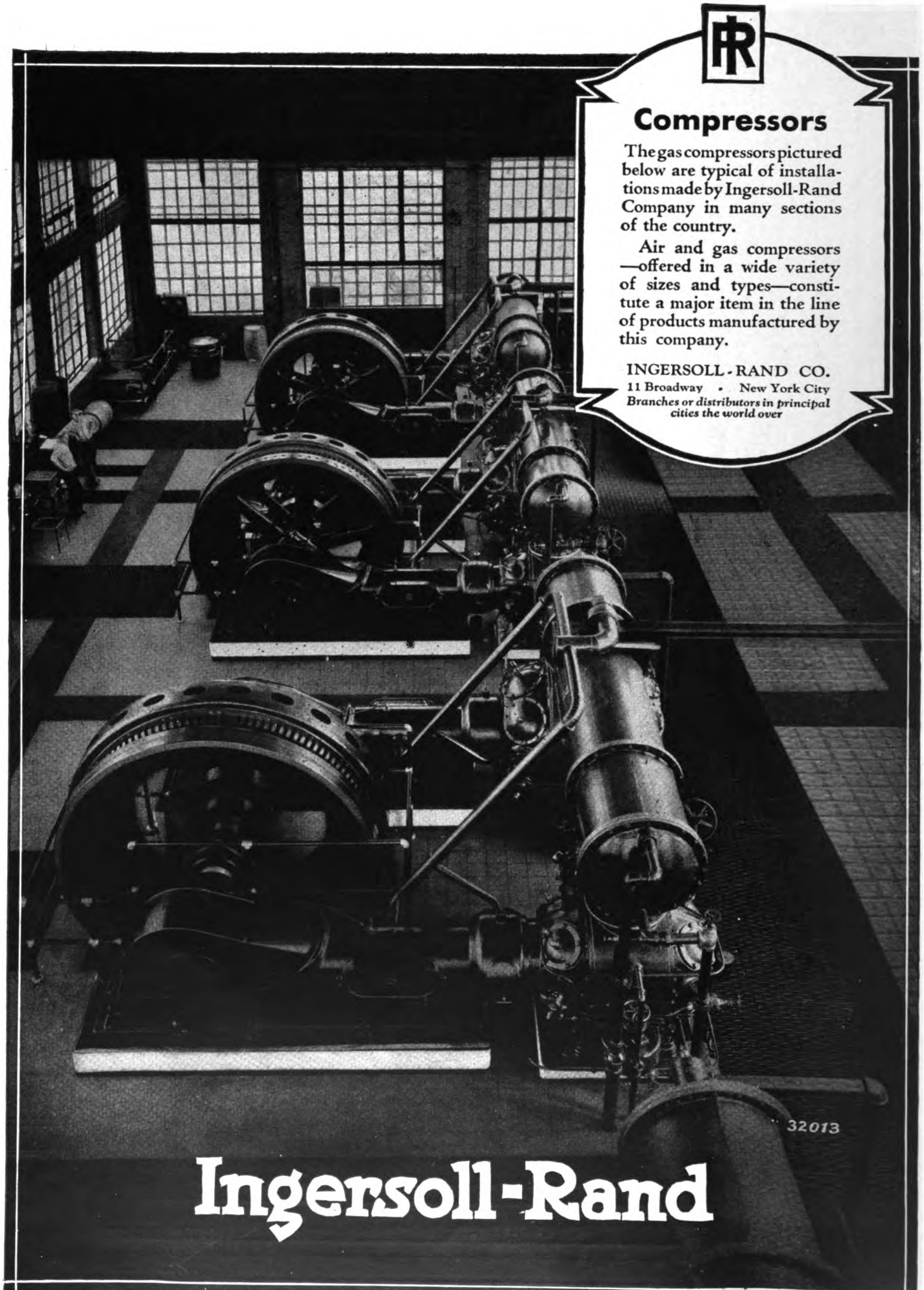
THE YALE SCIENTIFIC MAGAZINE

VOL. IV MARCH, 1930 No. 3

*Army experimental one-wheel Loening **Amphibian** with Wright Inverted Air-cooled Vee **installed**.*

(*See page 9*)

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL


Compressors
The gas compressors pictured below are typical of installations made by Ingersoll-Rand Company in many sections of the country.
Air and gas compressors—offered in a wide variety of sizes and types—constitute a major item in the line of products manufactured by this company.
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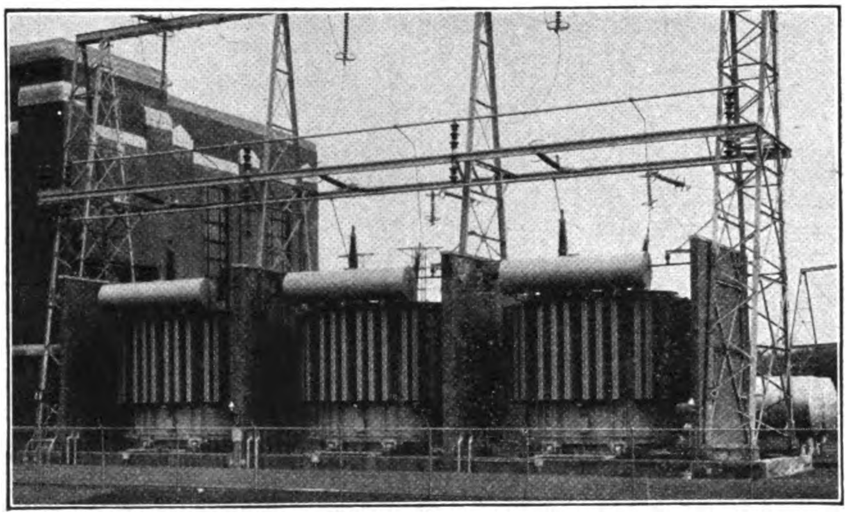
WHAT YOUNGER COLLEGE MEN ARE DOING WITH WESTINGHOUSE



Special cars were needed . . .

railway tracks had to be lowered, to handle the transformers these men built

AT CONOWINGO, Maryland, is the second largest hydro-electric development in the world. Power generated there at 220,000 volts will be fed into lower voltage transmission lines of the Public Service Electric and Gas Company at Roseland, near Newark, New Jersey.

The transformers that will perform this transfer of energy are physically the largest ever built, for their capacity is sufficient to serve the home lighting needs of a city of a million people. Four in number, each is larger than a house, weighs when empty as much as a large locomotive and holds three tank cars of oil. Four specially built railway cars and fifty-two standard cars of various types were required to transport them from the factory to the job. At one point the railway tracks had to be lowered so the units would clear an overhead viaduct, so great was their size.

When spectacular jobs like this come up it is natural that they go to an institution like Westinghouse. Pioneers in electrical development, Westinghouse engineers often know the thrill of achieving the "impossible" in seeing their work through from design to erection.

Westinghouse

E. W. TIPTON
University of Kansas, '25
Development of Commercial Design

R. L. BROWN
Ohio State University, '22
Tap Changer Development

EMIL STEINERT
University of Minnesota, '25
Electrical Designer

A. C. STAMBAUGH
University of Pittsburgh, '24
Engineer of Tests

H. H. WAGNER
University of Illinois, '27
Designing Engineer

THE YALE SCIENTIFIC MAGAZINE

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Subscription rate, $1.50 per year. Single copies, 40 cents. Advertising rates upon application.

WITH this issue the Yale Scientific Magazine completes its third year of publication. The Seniors turn over the management of the board to the 1931 board fully confident that its members will carry on the work to the best interest of the magazine and of the Sheffield Scientific School which it represents. During these three past years the magazine has advanced from very humble and somewhat timid beginnings to what we feel is a representative position among the undergraduate publications of the University.

A new competition for positions on the board opens shortly to Sophomores in the Scientific School. Since this is a Sheff magazine, it behooves Sheff undergraduates to support it. The members of the retiring board feel that the effort involved in the work they have done has been well spent; the rewards are in experience, and in the opportunities to come in closer touch with the workings of the scientific side of the University.

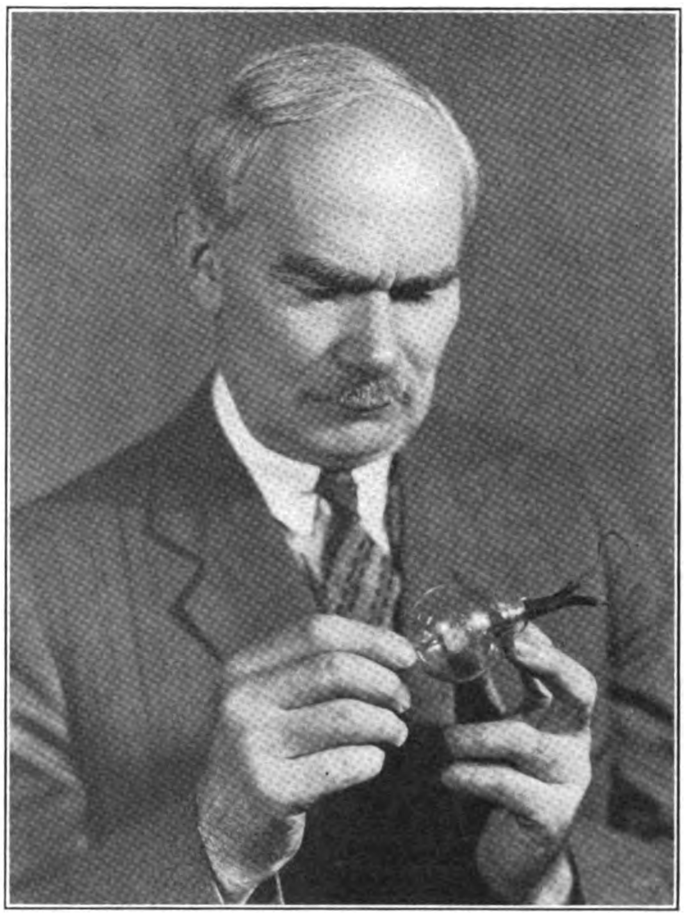
The policy of more undergraduate articles, articles not necessarily of direct scientific substance, seems to be working out well. It is difficult to find among the student body men of sufficient experience to develop a comparatively new and advanced treatise on science or engineering. But undergraduates can write on their own problems. The second such article appears in this issue: S. P. McCalmont, 1930S, discusses the Sheff point of view of the Freshman choice, which is not far ahead. If this article and the one similar to it in the January issue helped any Freshman in his decision part of our purpose will have been served. The rest, —to provide an organ for public discussion of Sheff problems,— depends upon time and upon our successors.

Lee deForest, Inventor of the Audion

The Invention and Development of the Audion by Lee deForest '96S., Has Led to Great Strides in Scientific Research.

AS a crowning honor in his career Lee deForest has recently been elected President of the Institute of Radio Engineers. As the inventor of the audion his name is familiar wherever radio is known. This invention, which has made radio communication in its present form possible, makes him one of the outstanding figures in the field of electrical communication and science today.

Dr. deForest descended from Dutch ancestors who came to this country in 1636. He was born in Council Bluffs, Iowa in 1873, and most of his childhood was spend in the west and south with his father, the Rev. Henry Swift deForest. His training in these small communities affords an easy explanation of the individual habits and inquisitive nature which have manifested themselves throughout his life. His early reading material consisted in the *Youth's Companion*, *Encyclopedia of Science*, and the *Patent Office Digest*—certainly a fitting background for an eminent scientist. He prepared for college at Mt. Herman School in Massachusetts, and in 1893 he entered the Sheffield Scientific School.



During his college career he was an Editor of the *Yale Scientific Monthly*. After receiving his degree in Mechanical Engineering in 1896, he remained at Yale for three years doing graduate work in physics and mathematics, receiving the degree of Doctor of Philosophy in 1899. The subject of his Doctor's thesis was "The Reflection of Hertzian Waves along Parallel Wires". This gave him first-hand information regarding waves and was the foundation of his earlier work in wireless. After leaving Yale he worked for a year at the Experimental Laboratory of the Western Electric Company in Chicago. He left this organization so that he could devote his entire time to developing the germs of what later became the deForest Wireless Telegraph System at the Armour Institute.

For the first few years of the century his work was amplified and put to first one test and then another. The year 1902 saw the organization of the American deForest Wireless Telegraph Company. In this early period Dr. deForest adopted many radical changes which were subsequently embodied in every system. Among these were the use of a self-restoring detector instead of a Marconi coherer, the telephone receiver in place of the relay and Morse inker, and the alternating current generator and transformer instead of the induction coil and interrupter. The great advantages of the new system were first demonstrated abroad in 1903 in the now historic tests for the British Post Office between Holyhead and Howth, across the Irish Sea. In 1904 the deForest System achieved world recognition through the spectacular success of the London Times War Correspondent, Capt. Lionel James, in reporting the Naval maneuvers around Port Arthur in the Russian-Japanese War. In the summer of that year the first commercial overland wireless service was opened, between the St. Louis Exposition and Chicago. As a result of this progress the United States Navy in 1905 authorized deForest to construct for it its first high powered wireless stations at Colon, Guantanamo, Porto Rico, Key West and Pensacola.

In 1906 deForest made public what has since proven his greatest invention, one which made possible trans-continental telephony, by wire as well as by wireless; this was the Audion, or thermionic detector and relay of minute electric currents, the heart of all present radio transmitting and receiving apparatus. He first applied it as a detector for use in the first successful radio telephone system, to which he devoted all of his efforts from 1906 to 1909. In 1908 all of the Battle Ship and Destroyer fleets of Admiral Evans were equipped with the deForest Radio Telephone, and the success attained at that time was largely due to the excellence of the Audion detector. In 1908 war ships of the British and Italian Navies were also equipped with the deForest telephone. But difficulties inherent to the arc type of transmitter which was then employed lead deForest to abandon this type, and from 1909 to 1911 most of his efforts were devoted to development of the "quenched spark," type of wireless telegraph transmitter, the germ of which deForest brought here from Germany.

In 1912 Dr. deForest exhibited his Audion relay, or telephone repeater to the engineers of the American Telegraph and Tele-

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A Sheff Man Presents His Viewpoint

The Scientific School Offers a Liberal Education which Develops Precise Engineering Thinking as Well as Excellent Fraternity Life.

By S. P. MacCalmont, 1930S.

SHORTLY after Easter, the members of the Class of 1933 must decide whether to continue education in the college or in the Sheffield Scientific School. There is a natural division of students between the former for those interested in art and letters and the latter for those who desire technical engineering, but the division is not so obvious for those preparing for medicine, law, finance, and industry. Sheff has advantages with which Freshmen are completely unfamiliar and to which we invite comparison of those offered by Ac.

Our first consideration is naturally an investigation of the educational policies of the two schools. Sheff has always been committed to a program of progressive pioneering instruction. The extensive study of the dead languages was a live requirement in the college until Sheff's famous Select Course, by proving its superiority, forced the modification of college curriculum to its present standard. While Ac has been catching up Sheff has again advanced and has developed courses in broad scientific education of equal importance to its first improvement. Economics, theoretical and applied sciences, cultural and broad subjects of general knowledge are now welded together to form the Industrial Engineering and Applied Economic Science Courses. Recognition of the merit of such courses is now general. Dean Pound of the Harvard Law School and President Hutchins of Chicago University both recommend scientific courses as the best basis for the successful study of law. Industrialists tell us that the great need today is for men who have general knowledge along these broad scientific and practical lines so that they can direct specialists and technicians with greater competence, and understanding. A man's knowledge in any field is necessarily incomplete if he is not acquainted with scientific management, machines, and power in industrial work, or if he does not know economics so that he can comprehend accurately financial matters. He must know, furthermore, how to handle men easily and smoothly. These are the ends toward which this progressive scientific education develops the abilities of the undergraduate.

In all matters where the word, science, is mentioned, there is the common undergraduate misconception that it means the memorizing of a bewildering mass of useless technical detail. True there are a few courses which might be so considered, but most Sheff courses are little concerned with extreme technicality, but train men to think over a problem logically, thoroughly, in the light of all possible affecting circumstances, conditions, and knowledge, with the view to drawing accurate conclusions. Courses teaching this method of thought may be said to be truly scientific. When some cultural subjects are added to broaden the student, then he becomes a product of scientific education. He has at his command a scientifically trained mind which the college graduate will find it difficult to mould by self-education and he has developed a taste for culture which he himself can satisfy. This is the contribution of Sheff to the development of an educated man.

Admitting the desirability of the instruction secured in Sheff, some men have deluded themselves into supposing that they could attend the college and elect the scientific courses with the same result as attendance in Sheff, but it cannot be so. One's field of knowledge would be materially limited and the nicety with which courses follow and hinge upon each other would be partially lost if not completely destroyed. To secure the practical benefits of a scientific education, one must attend a scientific school.

Other factors than those of training naturally influence each man in making his selection of Ac or Sheff. Most important of these, perhaps, is the superior social life which Sheff enjoys. Luxurious houses are your home for two years, and you have that fellowship which arises where a completely congenial group of men live together. That intimacy is established which breeds true friendship. In addition nowhere in college have purely social events obtained that measure of success which our Sheff Houses enjoy. Our parties, dances, teas, and breakfasts form the greater part of the undergraduate social life. No Sheff man who has ever lived in a house would exchange that privilege for membership in the best college fraternity and the best room in Harkness Quadrangle. The introduction of the House Plan is admittedly an attempt to give the college some measure of the social benefits now enjoyed by the Sheff. fraternities.

As for these Fraternities, the superiority of Sheff is widely recognized. They are small being confined to twenty-two men from each class. The interest within the fraternity is strong and constitutes a refreshing contrast with the blasé attitude of the college. Practices such as Calcium Night and Running Week with the hazing they involve are regarded as childish. We pride ourselves upon our dignity and sincerity. We have raised our fraternities to a level with which we invite comparison. Our relationships have more significance than the formation of eating clubs which supply their members with a questionable degree of social distinction.

Sheff can supply its students with as great if not greater opportunities for privileges, extra-curriculum activities and distinctions than can Ac. We are allotted four major managerial competitors to six from Ac. In most other matters the two schools are represented equally although Sheff is only a third the size of the college. This means that because of our small numbers we can offer a larger percentage of our student body a chance to secure distinction and responsibility. We are welcomed without discrimination in all University activities and have some which are peculiarly our own such as the unique *Scientific Magazine*. We also have counterparts of all those institutions which are peculiarly academic; Tau Beta Pi is an engineering Phi Beta Kappa. We have our own Student Council and Discipline Committee. There are the Senior Honorary Societies of Aurelian and Torch. Lastly, we have the privilege of being men of honor working under a student enforced honor system.

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The Bingham Oceanographic Collection

The Expeditions for Discovering New Species of Deep Sea Life Have Resulted in Investigations of Value.

By A. E. Parr

As it is now deposited in the Peabody Museum the Bingham Oceanographic Collection represents the results of three oceanographic expeditions planned, equipped, and conducted under the personal leadership of Harry Payne Bingham, 1910, on his yachts the Pawnee I and II.

The First Expedition (1925) visited the West Indian waters and the coast of British Honduras, mainly concentrating upon the collection of shallow-water forms and the organisms of the bottom down to a depth of about five hundred fathoms. Twenty new species of shallow-water fishes and seventeen new species of crustacea from various depths have already been described from the material obtained in 1925.

The Second Expedition (1926) made its most important collections in the Gulf of California, a comparatively unexplored faunistic region. Fifteen new species of fishes have already been found in this material, not including the deep-sea forms, which are considerably more numerous than in the West Indian collections from the previous year.

During the Third Expedition (1927), visiting the waters around the Bahama and Bermuda Islands, the work was concentrated upon the exploration of the bathypelagic strata at a depth of five hundred to a thousand fathoms. A special circular net, fourteen feet in diameter at the opening, had been made for this purpose and is probably the largest net of its kind ever used in deep-sea investigations. A very great number of new or little-known, free-swimming deep-sea forms were thus captured, forty-two new species of three groups of deep-sea fishes alone having already been described. The total number of new deep-sea fishes from this Expedition probably will amount to about sixty or more species.

Strange Fishes from the Deep Sea.

While many new or little known animals were brought to light from all regions visited during the various expeditions, as already above mentioned, the results of the greatest general interest were undoubtedly those obtained from the dark, bathypelagic depths of the ocean, the home of the luminous, as well as of the blind fishes, of the most ferocious, as well as of the most extremely defenseless forms. There is a new species, *Linophryne brevibarbis*, a horrid looking devil fish, all mouth and spines, and with a luminous bulb carried on a jointed and movable stalk from the snout. Another fish is a still more peculiar new relative of the devil fishes, *Thaumatichthys binghami*. In this species the luminous bulb is no longer movable, but projects straight forward from the upper lip, a certainly most advantageous position if it should function as a lure for whatever animals these fishes may prey upon, as assumed by many authors. *Thaumathichthys*, however, also shows another, still more unique peculiarity in its structure. The lower jaw can not meet the upper jaw (with the teeth); to close the mouth the latter must therefore be folded like the flaps of an envelope entirely around to the ventral surface. Our first illustration shows a case in which the reduction of one group of sense organs (the eyes) would seem to have been compensated for by an enormous development of another group, namely the lateral line canal system, which is now believed to serve for the perception of moving bodies in the water, through the waves they emit. In our second picture we finally see a form in which the eyes have become so extremely reduced as to be probably no longer functional; and this figure also illustrates one of the most annoying difficulties the collector has to contend with, when trying to obtain these soft skinned deep-sea fishes. Thanks to the voracious appetite of the deep-sea shrimps, which are also always present in the hauls, the poor specimen has become completely skinned on the way up, so that only a few black tresses remain along the bases of the fins. In this case, however, the crustaceans had fortunately made a very neat job of it, so that no damage had been done to the body underneath the skin.

The entire collection of fishes will amount to about three thousand catalog numbers, among which will be about a hundred new species, in addition to many rare specimens. The collection of invertebrates will probably reach similar figures.

In addition to the preserved material, the collection also contains about one hundred and twenty mounted specimens of various fishes, which now form a very valuable addition to the exhibits of the Peabody Museum; it further contains about forty paintings from life in which about one hundred species are

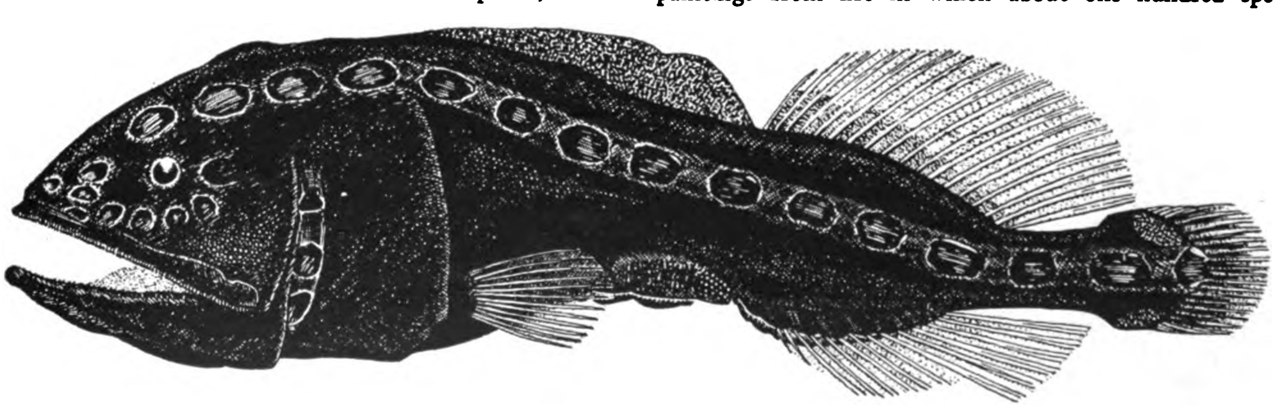

Fig. 1. Cretominus Storeri. (Goode and Bean).

represented; and, finally, a great number of color sketches, carefully prepared in the field, which very materially increase the scientific value of the preserved specimens. The above mentioned paintings and sketches are all from the hand of Mr. W. S. Bronson, the artist of the three expeditions, and the mounted specimens have been prepared by Mr. F. West, who also studied his material in the field.

After the return of the various expeditions the accumulated material has been subjected to investigations by various scientists and the anatomical, systematic and biological results of this work are published in the two series issued by the Bingham Oceanographic Collection. Fourteen articles aggregating about seven hundred pages have already appeared. During the first years, until the spring of 1928, the Bingham Oceanographic Collection was kept in New York, and there became established as a new factor in marine investigations through international exchange of its publications, which began to appear during 1927, and immediately gained acceptance among other domestic and foreign institutions working along similar lines. Through these exchanges a very valuable library of current scientific literature has accumulated, and will continue to accumulate in the future.

Mr. L. L. Mowbray, then of the New York Aquarium, who accompanied Mr. Bingham as ichthyologist on the first two expeditions, took care of the collections up till the summer of 1926, when he left New York to take charge of the new aquarium in Bermuda. For the third expedition the writer was then employed as zoologist, and has since been in charge of the collection.

In the spring of 1928 the Bingham collection was moved to the Peabody Museum, by a temporary arrangement with Yale University, and it is hoped that the arrangement may be made permanent in the near future, the work and publications continuing as before.

As a special phase of the research work which is now being based upon the Bingham Oceanographic Collection may be mentioned the very extensive studies on the brains of fishes being undertaken by the University's department of Comparative Anatomy, under the direction of Dr. Burr. It is hoped by Dr. Burr that these investigations may serve to shed some light upon the functions as well as the evolution of the vertebrate brain in general. Fish brains have also been supplied to Dr. Charlton of the University of Missouri, for neurological investigations.

Cooperation with the United States Bureau of Fisheries.

While the general investigation of the already accumulated material is still being continued at the Bingham Oceanographic Laboratory, this work has now progressed so far that it was felt that other problems could also be taken up. In realization of the high scientific interest and great practical value of the investigations carried on by the United States Bureau of Fisheries an offer of cooperation was therefore extended to the said institution and a joint research program has been inaugurated by this last summer's work. According to this program the Bingham Oceanographic Laboratory has now become a center for the general study of the spawning and early life history of the North and Middle Atlantic fishes of the United States. For the purpose of these investigations a boat and crew were last summer placed at the disposal of the laboratory for four months operations in the Delaware Bay region, under the direction of the writer, in pursuit of the eggs, larvae and young of fishes occurring in that environment. The results of this cruise are at least quantitatively very rich, and a research assistant has been assigned to the Bingham Oceanographic Laboratory to aid in the further investigation of the accumulated material, while another of the Bureau of Fisheries' investigators has also become attached to the Laboratory for the study of special problems. It is hoped that this cooperation may become further developed in the future to the mutual benefit of the purely scientific interests to which the Bingham Laboratory is primarily devoted, and of the practical interests of the fisheries administration.

As a final item pertaining to the activities sponsored by Harry Payne Bingham, through the medium of the Bingham Oceanographic Collection and Laboratory, may be mentioned that an advanced graduate course in the principles of marine biology is now being given by the writer, and has become included in the curriculum of the Department of Zoology of Yale University.

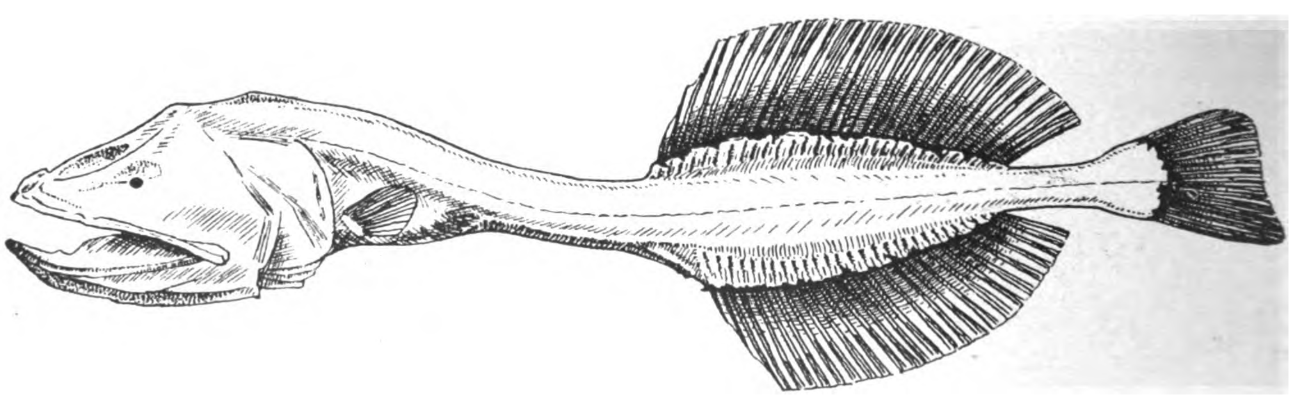

Fig. 2. Cretominus Regani. (Zugmayer).

Aviation's Trend Toward Inverted Engines

Research Since the War Has Led to the Development of Inverted Vee Engines with Air Cooling.

By W. H. Hunter, 1930S.

THE development of the aviation motor industry in this country since the world war has been marked by two tendencies: standardization on a few good motor types and refinement of design through constant experimentation. This development has been influenced by a desire to combine a maximum safety to the flyer with simplicity of operation and maintenance and aerodynamic cleanness of shape.

As a result the liquid-cooled Vee and the air-cooled radial engine have reached a high degree of mechanical perfection. Commercial aviation had to wait for the development of a satisfactory power plant and now owes its phenomenal growth to the success with which engineers have shaped the above mentioned types to meet their motor needs.

Of recent years almost the entire industry has turned to the simplicity and reliability of air-cooling for the solution of its motor problems with the result that the air-cooled radial motor has taken the lead in commercial installations. The increased demand for the radial motor, has hastened the solution of oiling problems and cylinder head cooling troubles neither of which had been satisfactorily worked out in the war-time rotary.

In an endeavor to satisfy more completely the interests of an increasingly air-minded public the aviation industry has branched off into two classes of manufacture: large transport ships and

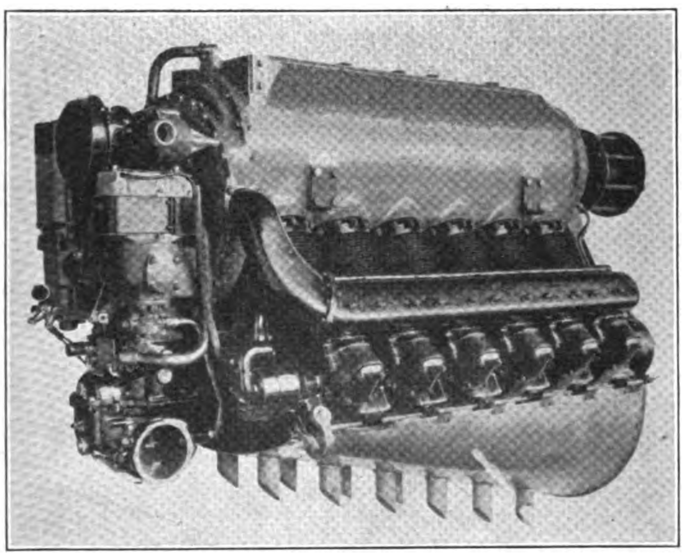

Fig. 1. Rear Quarter View of Wright Air Cooled Inverted 12 Cylinder Vee Army Pursuit Motor.

very small privately owned planes. It is in this latter group that the majority of producers are now interested. The growing demand for suitable small planes has led the airplane industry to develop some new types; in this class we find the light folding-wing biplane, the small low-winged monoplane, the flying boat and the amphibian. A recent review of the planes exhibited by manufacturers at the Air Shows of the past year indicates increasing popularity of the above mentioned types.

The new trend in plane design requires new motor types. To a certain extent manufacturers could rely on the wartime Ox-5, a very popular water-cooled Vee that is both cheap and reliable, and a smaller air-cooled radial that is lighter but more expensive. The installation of either of these types in one of the new light ships, however, leaves something to be desired. The former is heavy for its power and rapidly becoming obsolete; the latter offers too much air resistance unless it is used with the new venturi-cowling which has just been developed to improve the performance of radials; the new cowling has

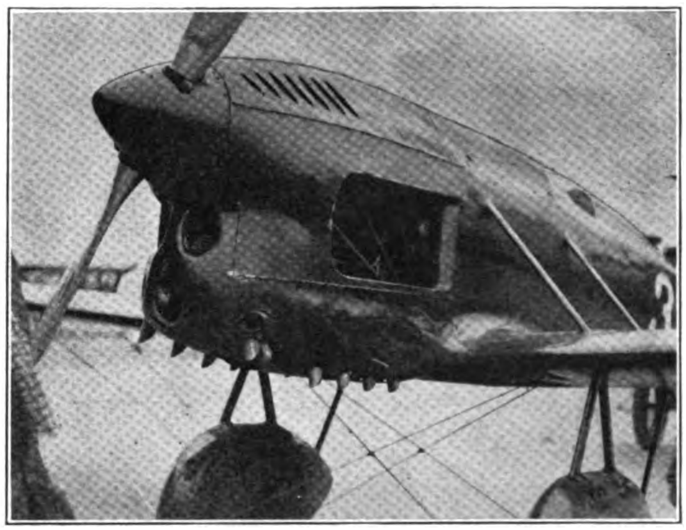

Fig. 2. Front view of Chevrolair Experimental racing motor in Travelaire Plywood covered mystery ship.

the disadvantage of added weight and interference with the pilot's vision.

Several large companies met the situation by designing air-cooled in-line motors of 4 and 6 cylinders to compete in the low-powered class. It is to be remembered that air-cooling originated with the radial form of motor. In the early designs cylinder construction was very much a question of experimentation and engineers relied on the equal cooling of the rotary to insure proper operation of the motor. As metallurgical and thermodynamical research continued, the technique of producing a cheap, rugged cylinder assembly of considerable thermodynamic efficiency was developed. As an experiment, Army engineers at McCook field converted the Liberty into a successful air-cooled motor. Air-cooling of an in-line or Vee-type motor was thus proved possible for the first time in 1919. Since then a number of companies have taken up the study of air-cooled in-line motors and have produced them in the past year when, for the first time, there has been a definite demand for them. This type possesses several distinct advantages over other existing types and is meeting with some favor in the airplane industry. The most important contribution it has made, however, has been in preparing the way for the latest type, one which com-

bines a greater number of desirable features in it than any other motor.

The new motor to which I refer is the inverted in-line air-cooled type; it is in every respect a conventional motor built to run upside down. One or two inverted motors built during the war attracted considerable attention and aroused engineers to consider the possibilities of developing such a motor on a practical basis. The idea was rejected by many engineers because they feared excessive oil flooding in the cylinders which hung below the crankcase. Apparently this was the only serious objection to inverted engines. yet it was sufficient to prevent further development for about ten years in spite of the fact that the inversion carries with it a number of advantages.

Radial engine development solved this lubrication problem and prepared the way for the inverted motor. The lower cylinders on a radial motor are inverted, yet the specific oil consumption of these motors is no higher than for upright in-line motors. Designers had found that extending the cylinder barrel

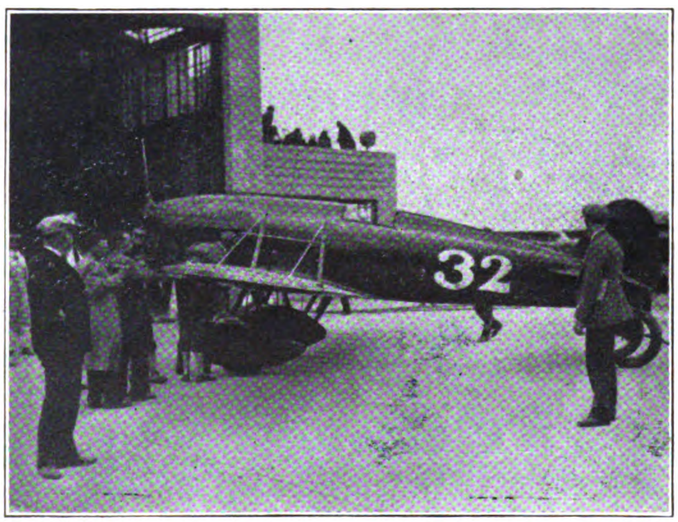

Fig. 3. Another view of the Mystery Ship.

into the crankcase for several inches prevented the oil which collects in the crankcase from running down into the cylinders. A study of lubrication taught them that oil could be carefully metered to the bearings under pressure and that the same oil could be pumped away from the crankcase as fast as it collected about the projecting ends of the lower cylinders. Oil was kept in an external tank and the motor was known as a dry sump motor. The quantity of oil in the motor at any one time is quite small and can be successfully scavenged. This lubrication system materially aided the development of the inverted motor.

Research on existing types of motors has thus made possible the combination of their best features into this new type by insuring adequate cooling and normal lubrication. The advantages to be gained apply equally well to any of the planes in the group mentioned earlier in this article. The following tabulation of the advantages will show the justification of the many efforts to make the inverted motor a success:

1. Higher thrust line—inversion has raised the position of the crankshaft relative to the center of gravity and the consequent raising of the slipstream gives greater efficiency and better controllability.
2. Ability to use larger diameter propellors—increased ground clearance due to raising the thrust line will permit the use of geared motors with large diameter slow-speed propellors; increased motor speeds are possible with geared motors and greater power can be obtained from a given engine displacement. In flying boat applications the increased hull clearance permits the use of a two-bladed instead of the less efficient three-bladed propeller.
3. Low center of gravity for motor mounted in plan with thrust line the same as with a similar upright motor. This is important in flying boats where position of control surfaces and hull require a high motor mount; lowered center of gravity insures greater stability for the plane.
4. Decreased head resistance compared with that of the uncowled radial. Better streamlining of the nose is possible due to the compactness of the in-line type which has a smaller frontal area than radial of same power. Since cooling is as good with the in-line as with the radial, nothing is sacrificed to obtain the cleaner lines, and the reliability of the air-cooled motor is preserved. The in-line air-cooled motor is as adaptable to the space and shape requirements of the plane designer as the water-cooled motor.
5. Better forward vision for the pilot—the small frontal area, the lowered mounting and the clean top of the motor (which is at most about 8 inches above the crankshaft center or thrust line) gives this motor a distinct advantage over other types. A venturi-cowled radial hampers forward vision. This factor is of especial importance in low-winged planes.
6. Better exhaust disposal and general heat dissipation—hot exhaust gases and hot air from cylinders are carried away safely below the ship and there is a minimum chance of fire or of bothering pilots with fumes and dirt from motor.
7. More even cooling of valves is made possible by running them in a bath of oil in the "underhead" camshaft housing. This will nearly obviate the trouble due to sticking or burning of valves and make the motor more rugged and safe.
8. Down draft carburetion is readily adapted to the inverted motor. This system insures better mixture and a more dependable supply of mixture to the cylinders since the flow is aided by gravity. The installation of a supercharger would eliminate the need of downdraft carburetion. but would be too costly for the present stage of the industry.
9. Motor is more accessible to ground mechanics for the inspection of spark plugs and valves. Removal of top plate permits easy inspection and adjustment of the crankshaft bearings.

All these advantages mean better plane performance, greater safety to the flying public and hence, an increase in demand due to a more satisfied public. Translated into dollars and cents this new type of motor will be a boon to the airplane industry in the small plane field where the advantages of the type have the greatest significance.

One could continue to enlarge on the advantages the industry will derive from the trend towards the air-cooled in-line motor

(Continued on Page 41)

Mental Disorders Treated by Psychiatry

A Description of the Various Types of Mental Disorders which are Studied and Treated by the Psychiatrist.

By Dr. C. C. Fry

PSYCHIATRY is that branch of medicine which has to do with the diagnosis, treatment and prevention of mental disorders. The term disorder is used instead of disease. The latter implies some definite change in tissue—some structural or functional changes in the organ; whereas most mental disorders are reactions to definite difficult situations and show no change in bodily organs.

The advances made in the medical world have been of a scientific nature. No longer are infectious diseases an unknown quantity; bio-chemistry has enlightened us. Diabetes, kidney disease and so forth, are understood in the light of laboratory findings and are treated according to results reported by test-tube and X-ray. Thus the impersonal factors in medicine have led to great advances, but what of the individual, the personality? He is more than a group of organs sewed up in thick or thin skin. There are medical symptoms, complaints and physical findings for which the so-called scientific approach can find no adequate explanation. The victims of these complaints go from physician to physician, visit cults, and quacks, make pilgrimages to shrines, take various patent medicines, but rarely find a solution to their conditions. Physical symptoms may be a question of change in the bodily organs. Vomiting may be due to inability to digest food; but it also may be due to inability to digest an unpleasant situation. A student in a small Eastern college complained of constipation only while in the college town. Change to a university near Boston freed him of this complaint. This was the method used by the student to get out of a situation which he found intolerable—namely the small Eastern college. It is as essential to study the patient's behavior through his personality and his attitude, his delusions and beliefs, his thwartings and his gropings,—in short, through the way in which he handles his problems, as to study the behavior of his bodily organs.

Each year about 70,000 new patients enter State Hospitals for the mentally ill. This is a goodly number, yet the figure is hardly representative of the problem. We are accustomed to classify these people as insane or at least abnormal, and are *led* consequently to classify ourselves as normal; yet the psychologist gives no adequate definition of the normal individual.

The average laymen has a good understanding of physical illness. He can talk of vitamins,—the effect of yeast on acne,—and he knows something of the general scientific trend in medicine. The term insanity leaves him with vague knowledge, perhaps with fear. He fights shy of acquiring any understanding of it. The average person would call a mental disorder a nervous break-down rather than insanity, and would seek shelter in that, to him, less damning term. Mental disorder, insanity, and nervous break-down are synonymous. After all, aren't they simply names descriptive of people trying to deal with life, finding it difficult to adjust themselves, groping for a solution of their difficulties, and finding that solution in a mental disorder? As the community comes to understand this fact a rational form of treatment for the individual can be instituted.

We shall arrange the mental disorders in three large groups for the sake of convenience. Let us call the first personality difficulties. Many people who are difficult to get along with or who find it difficult to adjust themselves to their environment are suffering from mental disorders. The individual who is moody, suspicious, seclusive, model or asocial may also be classed with this group. The person who has become eccentric, disagreeable, conscientious,—who has pursued intellectual knowledge, may have done so in order to find expression for an inadequate personality. Many of our own high standards, many of our good and bad personality traits, many of our emotional reactions, are manifestations of our gropings and our inability to find an adequate solution. An unhealthy reaction to authority may find its root in a family situation in which authority is a dominant and repulsive feature. The individual carries over this feeling of repulsion into his everyday life. The inefficient person or the one who is emotionally involved in adjusting his total personality may find it more agreeable to be forced out of his work by his employer's action than to acknowledge to himself his own intellectual inadequacy. Drinking may be resorted to in order to cover up moodiness, instinctive drives or unattractive personality traits. He may develop eccentricities in an effort to gain the attention essential to inflate his ego. These peculiarities may be considered preliminary skirmishes,—the desire to find a solution for some situation which we are unwilling to face squarely and to which we therefore try to adjust by the simple method of evasion. Not all people showing the above reaction are doing so because of a mental disorder. The "model" individual, the one in pursuit of knowledge, or the individual who feels discriminated against, in many cases finds a justifiable cause for his reaction.

The next large group shall be called the psychoneuroses. They are commonly labeled as the nervous and are said to be suffering from nervousness. A psychoneurosis is not a definite disease in the sense that smallpox or typhoid fever is; it is merely a type of reaction, and is classed with the minor disorders as are the personality difficulties. A psychoneurosis is a condition in which a person is unable to face squarely or adequately the demands of life. He evades unpleasant situations by inferior methods of meeting them. He converts his mental conflicts, his thwartings, into physical symptoms and comes to the physician to be treated for what he considers a physical disease. He unloads his troubles upon the physical symptoms, finding it much easier to talk of these symptoms. It is an unconscious conversion of the mental conflict into physical symptoms; he is not aware of this fact. An individual confronted with an unpleasant task may faint away and thus avoid the disagreeable situation; or he may develop blindness in order not to see it. If there are certain distressing or unpleasant situations in his past life he may develop amnesia,—a loss of memory,—a convenient method to escape a nagging or unattractive wife. He may pick

out bodily symptoms and unload all his worries and anxiety on them. So we may have a patient with some mild attack of indigestion who shows a disproportionate amount of worry over his condition. Headaches, dizziness, palpitation of the heart, paralyzed arms and legs, blindness or any physical symptom that you will, may be used as a method of escape, a weapon of defense or offense.

A young man of twenty-two was brought to the hospital with a paralyzed arm and leg. Let us see where these symptoms came from and what they meant to him. The patient was in love with a girl who would have little to do with him, and he was making no headway. He entered the National Amateur heavyweight boxing tournament hoping that he could win and thus prove his greatness and gain the girl's affection. Unfortunately he was told by a kind and well meaning friend that there was a contestant who was considered a "man-killer." His plans were upset for he had already informed the girl that he was going to box and therefore could hardly withdraw. Thus a mental conflict arose. Either way he was defeated. If he entered the contest he would be beaten and thus lose the girl. If he stayed out he would lose her respect. A few days later the solution came to him in the form of a paralyzed arm and leg and he was sent to the hospital, a place he considered proper in that it denoted sickness. His recovery was miraculous but he did not recover in time for the fight.

The psychoneuroses are commonly classed under a number of subdivisions, but their maladies can seldom be fully described by any one subdivision alone. They grade gradually from one to the other and are seldom found as a pure type. Most commonly a combination of symptoms is found, with the symptom of one type being predominant.

The psychoneurotic who converts the mental conflict into physical symptoms is said to be suffering from hysteria, and at one time these individuals made up a large proportion of the psychoneurotic group. Hysteria is a term so commonly and widely used, and so frequently misused, that it is rather unfortunate to employ the word. In the lay mind hysteria is synonymous with imaginary conditions. That is to say, the diagnosis of hysteria usually means there is nothing wrong with the patient; that he merely imagines.

The recent war showed us this type of reaction in its purest form. Here we see a large number of individuals who were unable to meet the demands of the dangerous and strenuous life at the front. The development of a paralyzed arm or leg, loss of sight, or of speech solved the problem for the individual by getting him away from the difficult situation, and at the same time preserved his self-respect, since he regarded himself as a sick individual and therefore entitled to be in a hospital. An authentic story is told of a whole company of British soldiers who lost their power of speech and were sent back to a base hospital where they were lined up and treated with an electric apparatus by a psychiatrist. As each man passed, the doctor applied the electrodes to the throat. Before he had reached half of the men the entire group was talking and singing.

Neurasthenia is a term applied to what is often characterized as nervous exhaustion. In this condition an individual is usually easily fatigued. He is very sensitive to outside impressions so that he often is bothered by loud noises, bright lights, etc. Here again physical symptoms such as headaches, stomach trouble, and complaints referred to the heart are very common. A large percentage of the general practitioner's patients is made up of this group.

Psychasthenia is a term used to describe a condition which is characterized by obsessions, phobias, and compulsive acts. Indecision is a prominent feature here. These conditions run one into the other. They take the form of ideas, fears, or acts which intrude themselves into the patient's consciousness in a manner he feels to be irresistible yet he recognizes these symptoms as foolish. You can imagine the hectic time a husband has when his wife considers everything he touches is contaminated and follows him about the home with a bucket of water and a box of Lux, cleaning up after him.

A married woman, fifty years of age, who was admitted to the hospital because she thought she had tuberculosis and cancer, would not bathe or handle objects which she feared had been contaminated or which she feared would comtaminate her son. She was described as a woman of good poise and balance, as sensible and efficient, as a leader in practical things. She enjoyed society and was much interested in her home. For several years she feared that she had tuberculosis and would contaminate things. She went to see several doctors and received some relief when she was told she was in good health. Her husband paid very little attention to the illness. She came in contact with an individual who later died of cancer. After this it was almost impossible for her family to live with her as she wanted to sterilize and scrub almost everything in the house. She was afraid that she would over-estimate or under-estimate her condition. Indecision was a prominent symptom as she made statements and then contradicted them. She was very anxious, feared death, was depressed and worried. She would not touch doorknobs, and washed her hands almost continuously. She felt that she had something on her mind which she had to tell but could not think of what it was. This is a mixed picture of anxiety, obsessions, phobias and compulsions.

There may be fears of closed or open spaces, fears of death, fears of committing murder; or some force may be compelling the individual to put on his right shoe first or to undress himself in a public place. If these acts are not carried out the patient feels that some terrible thing may happen, or he goes around with a feeling of guilt which colors his whole day. You may consider these symptoms as natural every-day occurrences for you may have seen individuals whom you consider sound possessing these eccentricities; yet they may be evidences of a true mental disorder which may or may not handicap the individual in his workaday life.

Anxiety states can be grouped with the psychoneuroses. These patients suffer from sleeplessness, show vague fears, are quite anxious about their condition, their hearts palpitate, and they are often quite sure they are going to die. This condition with some of its concomitant symptoms is commonly seen among the students, and may have behind it more than a mere fear of failing in academic subjects.

Thus the psychoneurotic group includes those individuals who convert their mental conflicts into physical symptoms, those with obsessions, phobias, compulsive acts and anxiety states.

We have discussed the mild mental disorders, the common or garden variety which we meet in our daily lives. There is a form of mental disorder which is due to disturbance of the glands of internal secretion, disorders of nutrition, toxic states, poison and changes in the brain due to structural damage. A delirium is a mental disorder as the patient is hallucinated, hearing or seeing non-existing things. He is disoriented and his

general behavior is out of keeping with his normal life. His memory is disturbed, his intellectual function interfered with, and his disorientation usually extends to time, place and person when there is some direct physical cause for his mental disorder. On the other hand the picture may be the same as has been previously described, or it may be the type which we shall now describe. In any case, however, it will be of great service to know something of the patient's personality, his thwartings, and gropings. To understand what a patient is endeavoring to accomplish while in a delirium may mean the difference between good and poor treatment.

A large and important division of the major mental condition is the affective disorders. They are so-called because the most prominent symptom is one of disturbance of mood. There are all degrees of this disorder varying from the marked depressions commonly called melancholia to marked elation. The patient in the depressed type of reaction is sad, inactive, often not interested in moving from one spot. He speaks seldom or not at all, for he has no interest in life. He is a sad dejected individual, unable to carry out his daily work because of the slowness of his thoughts. The patient is often self-accusatory, condemning himself for any of his past acts, feeling he has committed an unpardonable sin sometime in his life. The milder forms of depression often commit suicide. In the elated type of reaction the patient shows the reverse attitude. He is very active, overactive, on the go every minute, excited, in an exalted mood, and often destructive. His talk is continuous and flighty, jumping from one subject to another with no logical thought directing it. He may have delusions of grandeur, boasting of his strength, wealth and position in life. The milder forms often get into all kinds of social activities. They often enter into all kinds of foolish financial schemes or good plans. A salesgirl of twenty is a typical example. She was very elated; she said "I feel wonderful, I never felt better in all my life." There was overactivity in that she bought a diamond ring, wrote to many prominent people announcing her engagement, hired an apartment, bought furniture, coal, etc. to the extent of about five thousand dollars. She was making about twenty dollars a week. Her elation and good feeling were disarming to the shop keepers and it was not until it came time for payment that the girl's family had any inkling of her condition. She was then sent to a hospital where she stayed for about five months before she recovered.

Another major mental disorder is called Dementia Praecox and as its name implies, is a dementia of youth. As this condition is not found alone in youth and is not always followed by dementia, the term has been changed by some to Schizophrenia, a splitting of the mind. This mental disturbance occurs in the seclusive type of individuals. The symptoms are varied and it is a rather difficult group to describe. Often in a precocious youth there is a rapid dementia with hardly any other symptoms. It is characterized by a serious distortion of the patient's attitude towards his environment as shown by his delusions and hallucinations; a serious distortion of conduct as seen in his impulsive acts, odd attitudes and his withdrawal from reality. The patient is not interested in the world—his interest is confined to the world he creates within himself. His emotional life is often rather flat or distorted in that he may show no appropriate emotion. He may laugh when he should cry or cry when he should laugh. The disease may come to a standstill at any stage so that the patient may function at his own level and be considered as only an eccentric, a recluse, a tramp or a fool.

A young man, thirty-two years of age who was described as quiet, reserved, good natured, seclusive, entered a mental hospital because he believed himself to be a priest and desired seclusion. He had developed a delusion that the K. K. K., the Protestants, were after him and were trying to kill him and he believed himself to be a dethroned King. He traveled from city to city desiring to free himself of his persecutions. The trouble, according to his story, started after he had made a great actress fall in love with him. The fact that he thought he was a priest was dangerous, in that he thought he should hear the confessions of everyone, especially young girls. He had frightened some women by his insistence that he hear their confessions. In the hospital he acted the part of the priest. He was conscious of the fact that he was considered mentally ill as shown by some of his statements. "I am a priest but I am not doing anything about it now for it is quite a personal matter with me. You would probably laugh at me or say I was crazy." He believed that all the world had heard of him. He stated he could communicate with God. He would often contradict himself saying that he was a priest and then saying that he could not be a priest because his hands were blemished by manual labor and no man who had dirty hands could be a priest. It is interesting to note that after his admission to the hospital he dropped his ideas of persecution and became a great personage. He was devoid of emotion. The patient heard God talk with him and had visions of God. Later in his illness he developed the idea he was a thousand saints, thirty nine popes. His delusional system was built up around religious subjects. Thus he showed marked distortion; hallucinations both visual and auditory; distorted action in impulsive behavior in trying to force girls to allow him to hear their confessions; and in his seclusiveness. He is not unlike the paranoid cases but we would class him with the schizophrenic as there is more deterioration.

Not all schizophrenics have the religious trend. There is one form of the condition in which the patient becomes very quiet and can be moulded into all kinds of positions, is indifferent to the outside world, and sits about with absolutely no contact with his environment. Others show a rapid downhill process in their intellectual and general life, seeking much lower station than they had originally aimed for. Thus a precocious individual may suddenly give up his studies and become a tramp.

There is a condition commonly called paranoia which in its true form is rather rare. These conditions normally belong to the dementia praecox group. The paranoiac is an egotistical person, concerned with his own importance and grandiose plans; one who feels that he is being persecuted, discriminated against. People try to poison him, organizations follow him and desire to harm him; people steal his inventions and ideas. These patients are rather dangerous as they first run away, then begin to defend themselves, and finally take the offensive.

In general, the above gives us a description of the reactions of people commonly called "insane" by the laymen. Why not consider such people as individuals, meeting with difficult problems of life, finding no adequate solution and therefore taking refuge in their groping in a mental disorder. Why put a stigmata upon these individuals? All people suffering from mental disorders which the world so carefully conceals behind such terms as nervous breakdown, delirium and insanity are in need of alleviation of their sufferings. The classifying of these people as above often delays a rational form of treatment. It also delays the community in acquiring suitable knowledge in regard to this ill-

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Bacteriology as a Science and Profession

Yale Offers Excellent Facilities for the Study of this Science which Presents Great Possibilities as a Profession.

By Professor Leo F. Rettger

BACTERIOLOGY is today generally recognized as an independent science, instead of a branch of botany or pathology, or even microbiology, from which it has taken several decades to free itself. While it had its real birth only about 50 years ago, it constitutes a department of study which has been exceedingly prolific and far-reaching in its influence. It may be said, without serious contradiction, that it has made its importance felt in practically all phases of human activity. Bacteriology is distinct from the older, established sciences in that it requires and has developed a laboratory technique which is peculiarly its own.

Medicine has for many years been the chief beneficiary of the discoveries made by Pasteur, Koch, Von Behring and others who played such an important rôle in the development of modern bacteriology. Indeed, these discoveries were the foundation stone upon which a new system of preventive and curative medicine has been erected. Medical bacteriology will undoubtedly continue for many years as one of the most important divisions of the general subject, but there are certain fundamental aspects which make this science as decidedly a pure science as the other divisions of biology, for example botany and zoology, and as such it should and does supply basic information which can be applied in almost endless ways, as were the observations of Faraday and Franklin in the field of electricity, and of Dalton and Boyle in the study of gases. For example, the theory of spontaneous generation, which enjoyed such strong support in the 19th century, received its death blow only when bacterial spores and their peculiar resistance to high temperatures became known.

The field of general bacteriology has been divided into numerous branches, as a matter of convenience. Indeed, it is beyond reason that any one should attempt to master the subject as a whole. Specialization has attained the same degree of importance in this domain as it has in general chemistry and general biology.

Among the more important and established divisions of general bacteriology, besides Medical Bacteriology, are Preventive Medical and Public Health, Industrial, Agricultural, and Household Bacteriology, and their more restricted fields, Sanitary Engineering, Food, Water, Sewage, Fermentation, Soil and Animal Disease Bacteriology. There is a steadily increasing demand for trained and competent men in each of these fields.

The emoluments which bacteriology offers as a profession vary within very wide limits; in this respect there is quite a similarity between it and chemistry. Men and women just out of college who have had at least a year's training in bacteriology and accept positions as technical assistants in routine or research laboratories may start with a salary of from $1200 to $2000. Those who have acquired a higher degree, particularly the Ph.D., and who have made bacteriology their major study, may expect from $2000 to $3000 at the outset. For those who have satisfactorily directed control work or have conducted independent research many such positions should offer early and steady advancement, and after long and continued training and experience, a remuneration that is comparable to that received in the higher positions of the chemist and the engineer. This is particularly true in instances where men have attained to high positions as bacteriologists in industrial corporations, or where their professional services are sought as scientific experts and consultants.

There is a rapidly growing need of teachers of bacteriology in colleges, technical schools and universities, for men in subordinate as well as in highly responsible positions. Where such positions furnish ample opportunity for conducting and directing research, and at the same time adequate remuneration, they are becoming more and more attractive to men and women of outstanding qualifications; which is as it should be.

The Agricultural Colleges occupy a unique position among American Colleges and Universities in that they have recognized the importance of bacteriology and have developed the subject as a major department of study. The same may be said regarding certain engineering and technical schools or institutes. More recently bacteriology has received increasingly greater recognition by state and privately endowed universities.

During the past two years Bacteriology has enjoyed the status of a major department in Yale University. This was made possible partly by new facilities which permit the different divisions of bacteriology, together with immunology, to be housed under the same roof, in a new building (Brady Memorial Laboratory) which is admirably constructed and equipped for the purpose. The present system owes its existance also to a re-alignment of the hitherto separate divisions, whereby unnecessary duplication is eliminated, and greater correlation of courses and instruction in general is effected.

A half-year course in bacteriology furnishes the foundation work upon which all other courses in bacteriology and those in immunology and protobiology rest. This course is open to qualified students from all schools and departments of the University. Completion of this course permits students to enter the more special and advanced courses which are offered, namely public health bacteriology, soil bacteriology, physiology of bacteria, advanced Medical bacteriology and immunology, protobiology, research in the various divisions of general bacteriology and of immunology, and departmental seminars. This system has been in operation for only a year and a half, and may be said to be in a measure still experimental.

Ammonia Compressor Lubrication Tests

An Account of the Experiments Used to Determine the Fitness of Different Lubricants for Rotary Ammonia Compressors.

By E. J. Tavanlar, 1930S.

SOMETIME last year the American Society of Refrigerating Engineers (A. S. R. E.), through the Chairman of Research, Mr. Harry Harrison, announced a Research Contest with the view to arouse the interest of students all over the country in the science of refrigeration. Several papers, based on original researches, were submitted by students from as many schools and the judges selected four papers for the awards. The winners of the contest with their papers were Messrs. John C. Reed and Edgar E. Ambrosius, joint authors of "The Flow of Superheated Ammonia through Iron Pipes," both candidates for the degree of Master of Science in Mechanical Engineering, University of Illinois; Mr. Charles Keevil, a candidate for the doctorate at M. I. T., "Heat Transmission in the Refrigerating Industry;" Mr. Martin R. Borger, a graduate in Mechanical Engineering, of the Pennsylvania State College, "Rural Refrigeration," and the author, "Lubrication Tests with a Rotary Type of Ammonia Compressor." Each prize was accompanied by a certificate of award.

The student authors had an opportunity to present their papers on December 7 in connection with the Twenty-Fifth Anniversary Session of the A. S. R. E. At one of the technical meetings the student authors delivered their papers orally and an open discussion of each paper followed its delivery. The

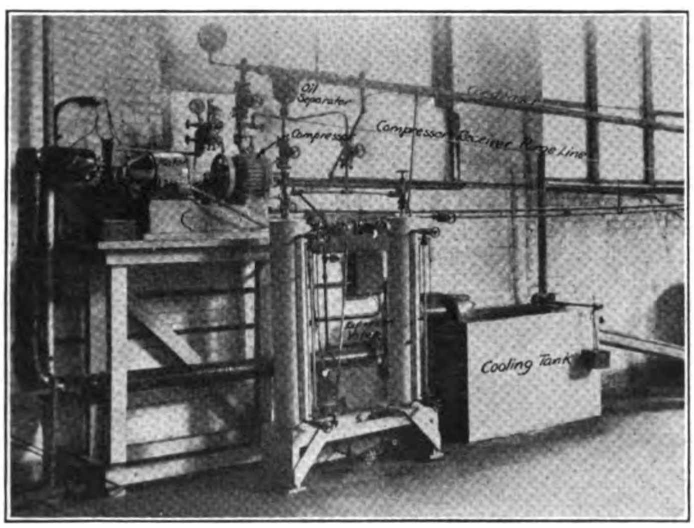

Fig. 1. The Refrigeration unit which was used in the experiment. Note the straight condenser which was designed and constructed especially for the experiment.

awards were also given at this session. The student papers were published in the "Refrigerating Engineering" of February.

Mention must be made of the interest and enthusiasm displayed by the members of the A. S. R. E., among whom are the foremost and pioneer refrigerating engineers of the country. Some of them, however, were reluctant to tax their gray heads in order to dope out the theoretical points in most of the student papers. The open discussion of the papers was brisk and instructive, and criticisms, constructive and otherwise, were made. The members of the awards committee also had an opportunity to comment on the papers.

If the author were to sum up his impression of the session of the A. S. R. E. he attended, he would say this,—that engineers, the refrigerating engineers in this case, discuss engineering problems in an engineering way, more from the *practical* point of view than the theoretical, and with the practical value of the problem to the engineering profession than to any particular industry or business in view.

The problem of lubrication is indeed important and its importance in refrigerating engineering is expressed adequately and straightforwardly by Professor A. J. Wood's, (former President of the A. S. R. E.), statement: "Lubrication is now a science.

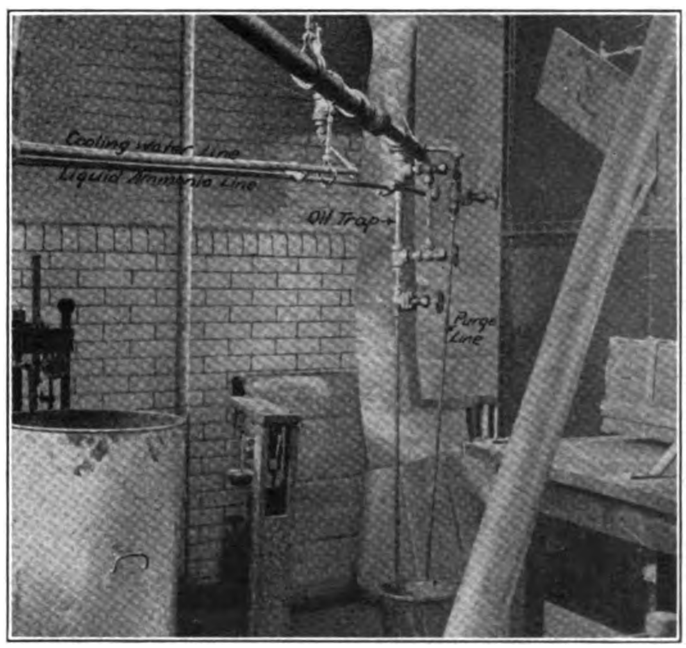

Fig. 2. The Liquid Ammonia End of the Condenser showing the Oil Trap.

Its value in engineering has not been emphasized to the extent that it deserves. Indeed in no other branch of engineering is lubrication so much overlooked as in refrigerating engineering." In view of this, a research on lubricants for refrigerating machines is especially necessary. I shall give an abstract of the paper as presented in New York.

The experiment was undertaken with the main object of finding a lubricant which is best suited for a refrigerating unit using a rotary compressor. Incidentally, the author undertook to find out the effects of ammonia on the specific gravity, flash point, fire point, cold point, pour point and viscosity of certain lubricants under the conditions existing in the compressor.

The space does not permit giving a detailed description of the test plant and subsidiary apparatus used in the experiment. It is hoped, however, that the accompanying pictures will give the reader an idea of the set-up of the experiment.

Five oils were tested. These are numbered consecutively from I to V for the purpose of the experiment.

Experimental Procedure.

Physical and Analysis of the Oils.

The viscosity, flash point, fire point, pour point, cold point and specific gravity of the Oils I, IV and V were determined before the experiment. These specifications of the Oils II and III were obtained from the company from which they were bought. The same physical properties were determined after each run of the oil from the compressor. The standard A. S. T. M. methods were followed in these determinations. Three determinations were made of each physical property.

Lubrication Test.

Before each run, if the compressor had been idle for two hours or more, the compressor was run until the temperature and pressures are fairly constant. This required from thirty minutes to an hour. A special oil was used during the warming-up run of the machine. After the machine was warmed up and the conditions fairly constant, all the valves were closed except the expansion valve, which remained at the trial run setting. The oil in the separator and oil trap was withdrawn and the oil in the compressor was replaced with the oil to be tested. The compressor was filled up to the "full" mark of the gage glass attached to it. In all the runs, the compressor case was filled with the lubricant up to this mark. The compressor was then run for one hour. Readings of the temperatures and pressures at various points and of the voltage and amperage were made at five minute intervals. The condenser water and the water from the cooling tank were weighed when occasion warranted. After a run all valves were shut, the compressor was emptied of the oil and then refilled with the oil to be tested. The separator and oil trap were emptied. The machine was started as soon thereafter as possible. The expansion valve was so adjusted that a suction pressure different from the one in the last test was obtained. The used oil from the compressor was sampled for the physical tests, and specimens of it were put in small bottles. The oil from the separator was measured volumetrically. Four runs were made with each oil.

Results and Discussion.

Table I gives the average values of some important items in the results. Table II gives the average values of the physical properties of the oils before and after the experiment.

The overall efficiency of the compressor-motor unit is rather low. The highest efficiency of 42.11% was obtained with Oil III as the lubricant. The efficiencies when the other oils were used varied as follows: 36.61% with Oil II, 32.52% wth Oil IV, 31.68% wth Oil I and 30.00% with Oil V.

The refrigeration unit gave the highest actual coefficient of performance with Oil III as the lubricant, with a coefficient of 5.55. The other values were as follows: 5.11 with Oil II, 2.69 with Oil IV, 2.18 with Oil I and 1.99 with Oil V.

With Oil II, the unit gave a tonnage of .971, which is the value obtained closest to the rated tonnage of one ton. The comparative tonnages with the other lubricants were .950 with Oil III, .432 with Oil IV, .360 with Oil I, .292 with Oil V.

The author contends that the lubricants affected the performance of the compressor in two ways. Firstly, the oils offered a resistance to the rotary motion of the moving parts of the compressor and to the flow of the compressed gas. The effect of this resistance would be shown in the capacity of the compressor with a given power input. Secondly, any oils that escaped with the compressed gas may have lowered the discharge temperature to a temperature considerably less than that which corresponded to the discharge pressure. The author is inclined to believe that this actually happened because the average

TABLE I.
Average Efficiency of Compressor, Actual Coefficient of Performance, Actual Tonnage of Machine, Efficiency of Condenser and Efficiency of the Cooling Tank.

Items	*Oil I*	*Oil II*	*Oil III*	*Oil IV*	*Oil V*
Overall Efficiency of Compressor	31.68	36.61	42.11	32.52	30.00
Actual Coefficient of Performance	2.18	5.11	5.55	2.69	1.99
Actual Tonnage of Machine	.360	.971	.950	.432	.292
Efficiency of the Condenser	100.54	102.21	101.75	103.96	103.51
Efficiency of the Cooling Tank	31.48	84.37	91.41	42.02	70.10

TABLE II.
Physical Specifications of the Oils Before and After the Experiment
Average Values

	Oil I		*Oil II*		*Oil III*		*Oil IV*		*Oil V*	
ITEM	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Specific Gravity	.905	.892	.875	.808	.920	.911	.891	.851	.871	.831
Viscosity (Saybolt)										
100°F	320	388	127	210	180	281	480	550	163	233
104°F	300	380	114	190	160	252	422	482	152	201
130°F	187	188	75	80	92	93	205	208	99	100
140°F	120	120	68	66	78	81	160	160	82	85
210°F	50	50	42	42	43	42	60	60	43	43
Pour Point	10°F	7°F	5°F	-2°F	-20°F	-28°F	10°F	7°F	8°F	5°F
Cold Point	15°F	12°F	10°F	2°F	-15°F	-23°F	15°F	2°F	13°F	10°F
Flash Point	390°F	390°F	365°F	365°F	330°F	335°F	410	410	380°F	380°F
Fire Point	545°F	550°F	405°F	405°F	375°F	375°F	460	460	445°F	445°F

discharge temperatures in all the runs are much lower than that corresponding to the discharge pressure after adiabatic expansion. The effect of this lowering of the discharge temperature, all other conditions remaining the same, would be to decrease the work of compression per pound of gas circulated. The combined effects of the lubricant would be evidenced in the overall efficiency of the compressor-motor unit and in the coefficient of performance.

In the following discussion of the effects of ammonia on the physical properties of the lubricants statements of the qualitative effects only are given. Insufficiency of the data precludes the making of statements of the quantitative measure of the effects. However, it is hoped that later supplementary data can be obtained from future tests by the author and by others.

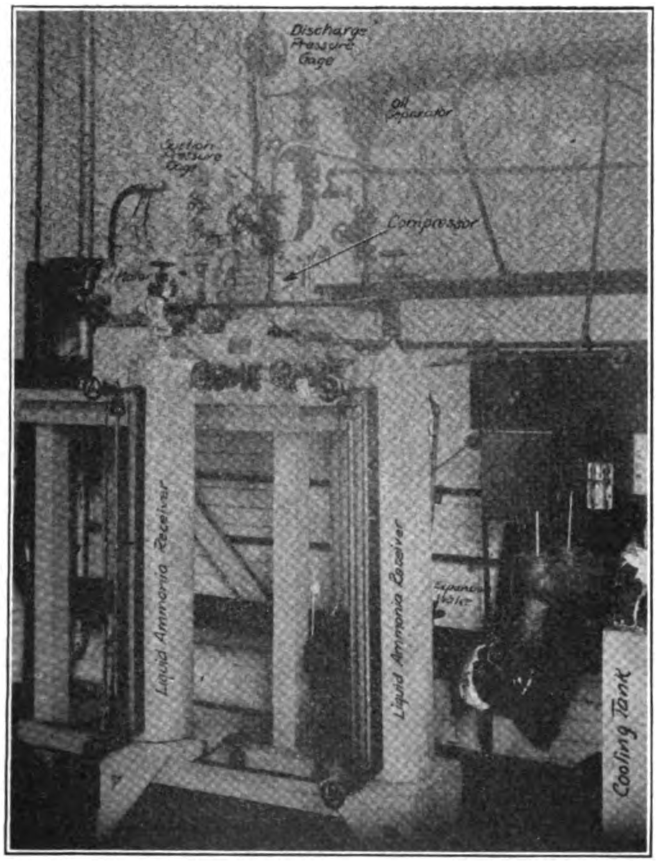

Fig. 3. A Closer View of the Motor-Compressor Unit showing the Various Connections.

The specific gravity of the lubricants was lower after the experiments than before. Various reasons are offered to explain this effect of the ammonia gas. First, the gas, being basic, may have reacted with and neutralized the acids that may have been present in the oil. For every unit volume before the neutralization, there would be an increase in weight with a relatively small or no increase in volume after neutralization, the increase in weight depending upon the degree of neutralization. Second, the presence of ammonia gas in emulsion or perhaps in minute suspension in the oil increases the weight without increasing the volume correspondingly.

The viscosities at 100°F and 104°F were greater after the experiment than before, the probable reason being that the ammonia present in the oil in any of the states mentioned above increased the molecular adhesion in the oil. The viscosities at the higher temperatures are materially unchanged because most

(Continued on Page 36)

OUR CONTRIBUTORS

Leigh Page who writes on Henry Andrews Bumstead in this issue is Professor of Mathematical Physics in the Sheffield Scientific School. He received his Ph.B. with the class of 1904S. He was given his Ph.D. in 1913. He is a past president of the Yale Chapter of Sigma Xi and has written many pamphlets and books.

E. J. Tavanlar, whose article on tests of lubrication on ammonia compressors, is a member of the Senior Class in Mechanical Engineering in the Sheffield Scientific School. He was born at Manila, Philippine Islands on December 1, 1906. After receiving a grammar and high school education there, he was appointed a Cadet at the United States Military Academy in 1925 by General Leonard A. Wood. He stayed at the Military Academy until December, 1928, when he transferred to the class of 1930, Sheffield Scientific School. After graduating in June, he contemplates taking up graduate work in Mechanical Engineering.

Alfred E. Parr, who writes in this issue on the Bingham Oceanographic Collection, is the assistant Curator of Zoology and has the rank of Assistant Professor at Yale University. He is in charge of the Bingham Collection at the present time.

Charles J. Daly, whose article on Coordinated Efforts of Public Utilities appears in this issue, received his Ph.B. degree from the Sheffield Scientific School in 1909. Shortly after graduation he accepted a position with the Southern New England Telephone Company. At present he is the Transmission and Protection Engineer of this Company.

Professor Leo Frederick Rettger, who writes on Bacteriology as a Science and a Profession, in this issue, has been Professor of Bacteriology at the University since 1919. He was born in Huntingburg, Indiana. He graduated from the Indiana State Normal School in 1894, and, from the University of Indiana, received his B.A. in 1896 and his M.A. in 1897. From 1897 to 1900 he held a position as Instructor in Bacteriology and Chemistry. He has studied at the University of Straussbourg, and in 1902 obtained a Ph.D. from Yale. Until 1906 he was instructor of bacteriology at the University, becoming Assistant Professor in 1906 and Professor in 1919. From 1903 until 1906 he was a Research Fellow at the Rockefeller Institute of Medical Research. In 1928 he was appointed Chairman of the University Bacteriology, Pathology, and Public Health Department. He is the author of many pamphlets on Bacteriology.

Doctor Clement Collard Fry, whose article on the psychiatric treatment of mental diseases appears in this issue, is Clinical Instructor in Mental Hygiene and Psychiatry at the University School of Medicine. After preparing at the Trinity Church School in New York City, he received his B.S. degree at the Michigan State College in 1917 and his M.D. from the Northwestern University Medical School the next year. In 1923 he became an Interne at the Louisville, Kentucky City Hospital, and in the following year was appointed Assistant Physician at the Boston Psychopathic Hospital. In 1925 he held a position as Medical Officer and Resident and also served as an Assistant in Psychiatry at the Harvard Medical School. He joined Yale in 1926 as a member of the resident staff of the Mental Hygiene Program founded then by the Commonwealth Fund. He is now associated with Dr. Kahn of Munich who is chairman of the Rockefeller Foundation program for the studying of psychiatry and mental hygiene at the University.

Coordinated Effort of Public Utilities

Due to New Developments in Apparatus and Methods of Operation, Increased Expansion, and Greater Requirements for Service Coordination is Necessary.

By Charles J. Daly

RECENTLY, in Dunham Laboratory of the Scientific School, a well-known power engineer talked to an audience consisting of the seniors of the electrical engineering course and representatives of many of the public utilities in Connecticut. The speaker gave a very interesting and instructive talk on some of his practical experiences in the engineering, construction, and operation of high tension power lines in both North and South America. Although his subject was primarily concerned with the problem of safely transmitting potentials in the order of 100,000 volts, he was very careful to stress upon his audience the necessity for also considering the effects that these same voltages, under both normal as well as abnormal conditions, might have on paralleling communication circuits where the potentials of the operating signaling currents are in the order of 100 volts and potentials of the voice frequency currents are in the order of fractions of volts. The extent to which this consideration of the effects of one utility on the service of another is carried, is something that is not generally known by the public at large, although it has become one of the major problems of the operating engineers of the various utilities and requires the greatest coordinated effort on the part of these engineers to design the plant and adopt operating methods that will provide the grade of service expected of them by their respective customers. It might be of interest, therefore, to mention briefly some of these considerations.

Public service to a community today is complex. By public service is meant that service which is essential to the civic life of a community, such as the service rendered by the Electric Light and Power Company, the Street Railroad Company, the Telephone Company, the Gas and Water Companies, and the Railroad Companies. Each utility is judged by the quality and dependability of the service it renders. Yet in rendering service each utility is dependent to a more or less degree on the services of the others and unless there is cooperation between them the service rendered by one can be interfered with or even disrupted by the normal operation of the others. When one realizes that the various utilities are striving to render their respective services to the same individual customer, it can hardly be denied that the rendering of a dependable public service to a community has certainly become very complex.

As to the extent of the dependence of one utility on that of another, one has only to mention that some of the street railway systems are purchasing from neighboring power companies the energy to operate their trolley cars; that the Telephone Company is depending more and more on the local electric light companies, and on the gas companies in cases of emergency, to supply energy to operate its complicated and highly specialized telephone system. In turn, the electric light and power companies and the street railway companies are relying on the Telephone Company to provide a dependable telephone service for dispatching purposes in connection with the operation of high tension power lines and the maintaining of the trolley schedules. This reliance on the telephone company also applies to the other utilities to a somewhat lesser degree. Only a few years back the power companies and the street railway systems owned and maintained their own telephone dispatching service. However, due to the rapid growth of the various public service systems and as each system is becoming more specialized and dependable, the respective utilities are recognizing the fact that the utility specializing in one type of service is the best fitted to provide that service. This dependence of the utilities on one another

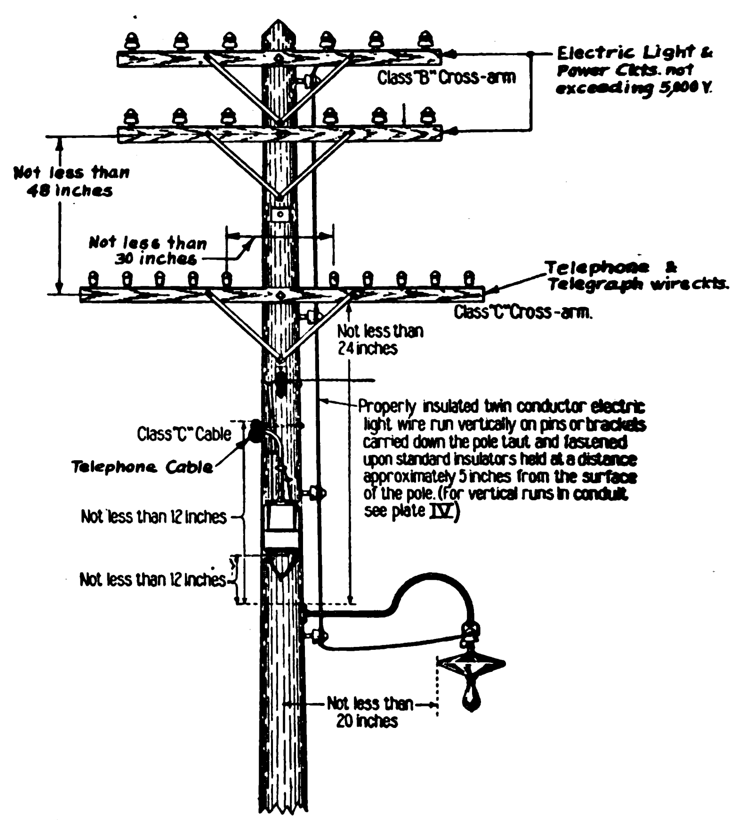

Fig. 1.

is giving them more of a joint responsibility to cooperate in maintaining their respective systems so as not to impair the service of any of the others.

For an example of how easily one utility can disrupt the service of another without interfering with its own service, the effects of stray trolley current on underground metallic structures may be cited. Many street railway systems purchase energy to operate its street cars from a power company. The power company usually delivers this energy in the form of alternating current to the sub-station of the railway system where it is converted to direct current either by rotary converters or, the more recent method, by means of mercury arc rectifiers. The tracks of the railway system are used as one side of the trolley circuit and as these tracks are imbedded in the earth the trolley cur-

rent returns to the sub-station not only by means of the tracks but some of it may stray into the earth and return partly by way of other underground metallic structures, such as the pipe lines of the gas and water companies and the lead sheaths of the underground cable systems of both the Telephone Company and the Electric Light Company. At the places where the trolley current leaves these underground structures and enters the earth to reach the negative bus of the sub-station, electrolytic corrosion, which disintegrates the metallic structure of the pipe lines and cable systems, takes place. This may go so far as to allow the leakage of water and gas out of the pipe lines or permit moisture to enter the cable systems and ground the electric light and telephone circuits, with an immediate interruption to the two latter types of service. One does not require much imagination to picture the results of the failure of a large water main which feeds a section of a city and on which the inhabitants as well as the operation of some of the other utilities may depend for their existence. However, due to the coordinated effort of all the utilities such a catastrophe of this magnitude rarely, if ever, occurs.

The Problem of Electrolysis Mitigation

Of all the problems requiring coordination of effort that of electrolysis mitigation seems to be one of the more complex, as it involves practically all the public service companies and in general any remedial measure applied varies in its degree of effectiveness for the various systems. It would be possible, to be sure, to apply a remedy that would safeguard the water pipe line but by so doing the corrosive effects on the electric light and telephone underground cable systems would probably be increased due to the interchange of the stray current from one system to another. The reverse would be true if the safety of the electric light system or of the telephone system only were considered. The method that is being used to solve these complex problems in Connecticut is to coordinate the efforts of the various utilities by means of an "Electrolysis Committee" consisting of technical representatives from each of the various utilities involved in each particular city or area.

It is the function of this committee, first, to ascertain the facts concerning the electrolysis conditions of all the underground metallic structures in the locality under consideration; to determine the best engineering solution for this problem, based on these facts; and then see that the remedy applied is effective. Even when the remedy has been applied the responsibility of such a committee does not end because the remedy does not always provide permanent relief due to the many variables involved. This committee, therefore, also acts as a clearing house of information and keeps the various utilities informed as to contemplated changes in any of the systems that may effect the electrolysis situation. This method of coordinated effort has been very successful in keeping down the interruptions in the services of the various companies to a very minimum.

Another instance may be cited where one utility could have operated its own system satisfactorily but would disrupt the service of another, if this spirit of coordinated effort did not prevail. In one of the large cities in Connecticut, the Electric Light Company considered changing its method of operation from a 2300 volt 3-phase 3-wire isolated neutral distribution system to a 4400 volt 3-phase 4-wire grounded neutral system. A short trial run of the electric light system operated with the generators and main transformers connected in one manner to their distribution system showed that the telephone service in many sections of this area would be seriously impaired due to the humming or buzzing noises that would be induced on the telephone circuits. It is of interest to note that this noise would be caused not by the fundamental frequency of the useful working voltage of the electrical system that the customers pay for, but by the harmonics of the fundamental that are also generated but serve no useful purpose.

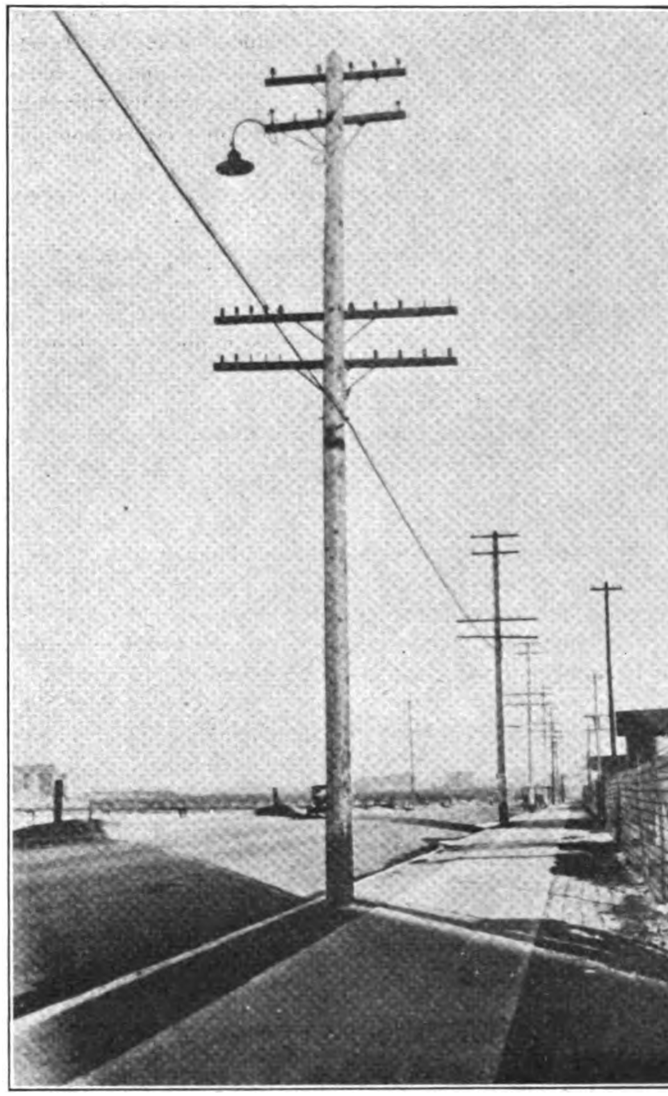

FIG. 2.

Here again, a conference was called of engineers from two of the largest manufacturers of electrical equipment, from the local Electric Light Company and the Telephone Company. A joint working committee was appointed to determine the facts and recommend the best engineering solution for operating the electric light service on the new basis. The solution of this problem consisted of making certain changes in the electrical connections of the generators and the main transformers at the power station which did not restrict the electric light service and also some changes in the telephone plant in certain areas. The result is that the Electric Light Company is now operating its distribution system as planned, without any appreciable interference to the telephone system, and the customers of both companies continue to receive dependable service.

(Continued on Page 36)

Henry Andrews Bumstead, 1870-1920

By Professor Leigh Page

HENRY ANDREWS BUMSTEAD was born in Pekin, Illinois, on March 12th, 1870. His father was Samuel Josiah Bumstead, a physician of local prominence, and his mother, Sarah Ellen Seiwell. His early education was obtained at the Decatur, Illinois, High School, from which he went to Johns Hopkins in 1887, expecting to study medicine. There he came under the influence of Rowland, who stimulated the interest in physics which he had already shown. After receiving his B.A. degree in 1891, he remained in Baltimore for two years as an assistant in the physics laboratory. In 1893 he was brought to Yale as an instructor by Professor Hastings. He continued his study of physics in the Yale graduate school, and obtained his doctor's degree in 1897. In 1900 he was promoted to an assistant professorship, and six years later he became Professor of Physics in Yale College and Director of the Sloane Laboratory. The year before receiving his doctor's degree he married Luetta Ullrich, of Decatur, Illinois, who survives him.

Professor Bumstead's thesis for the doctor's degree, which does not seem to have been published, contains a critical survey of electrodynamic theories in vogue at the time at which it was written. He states in the introduction that his object is "to set forth the true position of the experiments of Hertz in the history of the development of our knowledge of electricity; and to trace, in some measure, the influence of Helmholtz in the establishment of the true theory of electrodynamics,—an influence which was second only to that of Maxwell." After an analysis of Ampère's and Grassmann's theories, he makes a critical comparison of the potential theories developed by Neumann, Weber, and Helmholtz. The very general form of Helmholtz's theory appealed to him greatly, and he takes delight in showing how it contains as special cases most of the other theories proposed, including Maxwell's formulation of the results of Faraday's researches. Helmholtz's attempts to discriminate experimentally between various somewhat discordant viewpoints did not seem to him very conclusive, but his admiration for Hertz's genius knew no bounds. He lays particular emphasis on Hertz's zeal in following up every unexplained phenomenon to its source, mentioning in particular the discovery of the effect of ultra-violet light on the conductivity of the spark gap. His point of view throughout is that of the older British school of physicists, and it is evident that at this date the "ether" was very real to him.

During the five years following the completion of his doctor's thesis, Professor Bumstead's heavy teaching schedule left him little time for research. His interest in electrodynamics, however, was always keen, and in 1902 he published a short paper in which he showed how Maxwell's equations completely accounted for an anomaly in connection with reflection of electric waves which had been causing considerable discussion among experimentalists. If standing waves are set up on a pair of parallel guide wires terminating in a conducting plane at right angles to their length, the node in electric intensity found at the end of the wires is at a distance from the nearest node on the wire agreeing with the distances between other adjacent nodes. If, however, the conducting plane is removed, the loop to be expected at the free end of the wires is found to be at a distance from the nearest node somewhat less than a quarter wave-length. Bumstead showed that the introduction of a fictitious magnetic conductivity into Maxwell's equations established a close correspondence between this case and the well-understood arrangement in which the ends of the parallel conductors are united by a short connecting wire.

The year following the appearance of this paper, there fell on him the sad duty of writing the obituary of his friend and teacher, J. Willard Gibbs. His interest in and knowledge of mathematical physics enabled him to prepare an appreciation of the great physicist which could have been equalled by few of his contemporaries. Shortly after, he edited, in collaboration with Dr. Van Name, Gibbs' collected works.

Bumstead's interest was greatly excited by J. J. Thomson's investigations of the properties of cathode rays and it was largely through his efforts that the successor of Maxwell and Rayleigh was persuaded to come to Yale to deliver the first Silliman

Courtesy American Journal of Science.

lectures in May, 1903. While in New Haven Professor Thomson told him of the work being done at the Cavendish Laboratory on a radioactive gas found in water coming from deep levels, and suggested work of a similar nature at New Haven. This Bumstead carried out with the help of L. P. Wheeler. They found evidences of radioactivity not only in the gas driven off from water obtained from a well 1500 feet deep near New Milford, Conn., but also in that boiled off from surface water drawn from one of the New Haven city reservoirs. A comparison of the rate of decay of the soil-water gas with that of radium emanation showed the two to be identical. The rate of diffusion of the emanation through a porous plate was determined, and found to be about four times that of carbon dioxide. This led to an atomic weight of 180, which was, perhaps, the most reliable value which had been obtained up to that time, and, considering the difficulties of the experiment, surprisingly close to the value accepted today.

The winter 1904-5 Bumstead spent in England carrying on experimental work in the Cavendish Laboratory. This year's work led to the publication of two papers, of which the second, on the heating effects produced by Röntgen rays in metals, excited a great deal of interest. This investigation was undertaken at the time when the attention of the whole world was focused on the brilliant researches of Rutherford on atomic disintegration. Physicists were particularly interested in investigating the possibility of hastening radioactive disintegration by suitable external conditions, and in searching for new sources of radioactivity. However, every effort to control the rate of decay seemed to be in vain. From the lowest to the highest extremes of temperature, under all conditions of electromagnetic excitation, radioactive transformation went on at the same invariable rate. Bumstead's investigation consisted in measuring the heat produced in lead and zinc when Röntgen rays are equally absorbed in the two metals. His experiments seemed to lead to the very surprising result that heat developed in lead is approximately double that produced in zinc. The only plausible explanation was that the rays effected a disintegration of the lead atoms through which they passed, liberating energy which was then converted into heat. This result, if true, would have constituted the first successful attempt to effect an artificial disintegration of the atom. Unfortunately, however, the subsequent work of Angerer and of Bumstead himself failed to confirm the results of the earlier experiment. By varying the conditions of the experiment Bumstead was able to show that the differential effect observed in the first instance was due to faulty heat-insulation of the metals under investigation.

In the meantime Bumstead had returned to New Haven to succeed Professor A. W. Wright as Professor of Physics in Yale College and Director of the Sloane Laboratory. He soon realized the inadequacy of the old Physics Laboratory, and it was largely as a result of his efforts that William D. Sloane and Henry T. Sloane of New York were persuaded to give to the University and to endow generously the present commodious building. All those who have benefited by the facilities and conveniences of the new laboratory are under a great debt of gratitude to Professor Bumstead for his many months of painstaking planning and careful supervision of the erection of the building. In this new laboratory were housed together, for the first time, both undergraduate departments of study in a single subject. This union was the forerunner of the departmentalization which has been so prominent a feature of the recent University reorganization.

In 1905 appeared Einstein's epoch-making paper on the principle of relativity. Always interested in electromagnetic theories, Bumstead's mind was greatly stimulated by the new principle. In 1908 he published a critical comparison of the view-points of Einstein and Lorentz, and devised elegant methods of deducing some of the consequences of the theory. In particular, mention should be made of his derivation of the ratio of longitudinal to transverse mass from a simple consideration of the period of a moving torsion pendulum. In this paper he made some attempt to extend Einstein's method to gravitational problems, and pointed out clearly the fallacy of the oft-repeated assertion that a finite velocity of propagation of gravitational force should produce a first order perturbation in planetary orbits.

While Bumstead was greatly impressed by the beauty and symmetry of Einstein's theory, the ether had such a real significance to him that he was never able to accept completely the viewpoint of the relativist. Furthermore, he doubted the value of the new principle in opening up unexplored fields of research. To him it seemed like a closed system, perfect but infertile. Hence Einstein's ultimate success in generalizing the principle, so as to make possible the application of the equivalence hypothesis to gravitational fields, appealed to him all the more as a great work of genius.

In 1911 Bumstead turned his attention to a study of the delta rays emitted by metals under the influence of alpha rays, which he continued for the three following years. Delta rays—so named by J. J. Thomson—are the slow-moving electrons detached from metallic atoms by the impact of the more massive alpha particles. The ionization curves obtained by Bumstead show all the characteristics of the Bragg curves for gases, but unlike the latter, the curves for different metals have very closely the same form. This led him to suspect that the delta rays come from a gas absorbed on the metal surface. An investigation of the velocities of the particles constituting the rays revealing the fact that some of them have velocities corresponding to a potential difference as great as 2000 volts. These swifter rays seem to be the primary result of impact of alpha rays, and to give rise to secondary slow-moving electrons when they collide with other atoms. The result of this experiment suggested to him that fast-moving electrons may also be produced when gaseous molecules are struck by alpha particles. To investigate this matter, he obtained from England an expansion apparatus made after C. T. R. Wilson's design. This apparatus he modified so as to enable him to work in hydrogen at a pressure of 100 mm., and with it he obtained a number of photographs of alpha ray tracks, which showed very clearly electronic trails radiating from the column. These trails are undoubtedly due to swift delta rays.

In addition to the papers published under his own name, Professor Bumstead supplied the underlying ideas and much of the motive force responsible for the great majority of doctors' theses in physics coming from Yale during the last fifteen years. He was always generous in giving his time and ideas to others, and never asked the students who worked under him to share with him the credit of authorship.

Recognition of his ability as a scientist has come from many sources. Long a member of the American Physical Society, he has been its president and an editor of its organ of publication, the *Physical Review*. As Vice-President of the American Association for the Advancement of Science, he delivered the annual address at the meeting in Pittsburgh in December 1917, choosing

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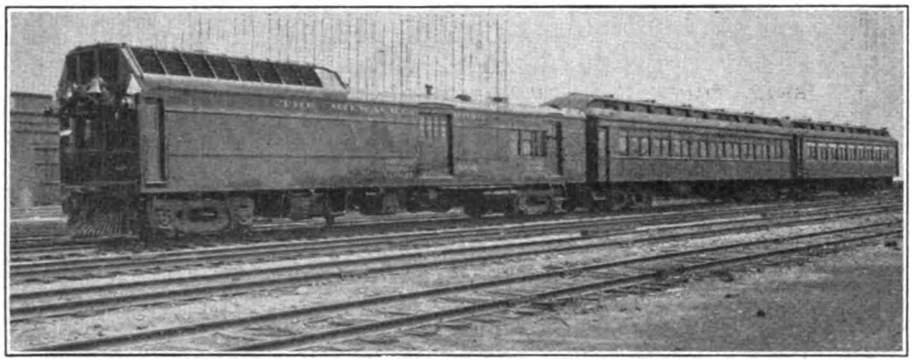
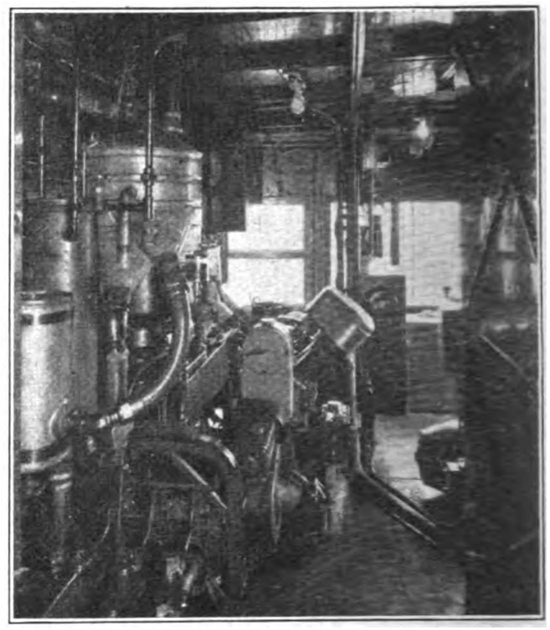


ABOVE.—*A Steam-powered Rail Motor Car now in service on the Milwaukee Road. It is driven by two special 8-cylinder Uniflow Poppet-Valve Steam Engines which operate on less than eleven pounds of steam per horsepower hour. It contains as well as the engine room a baggage room and mail room.*

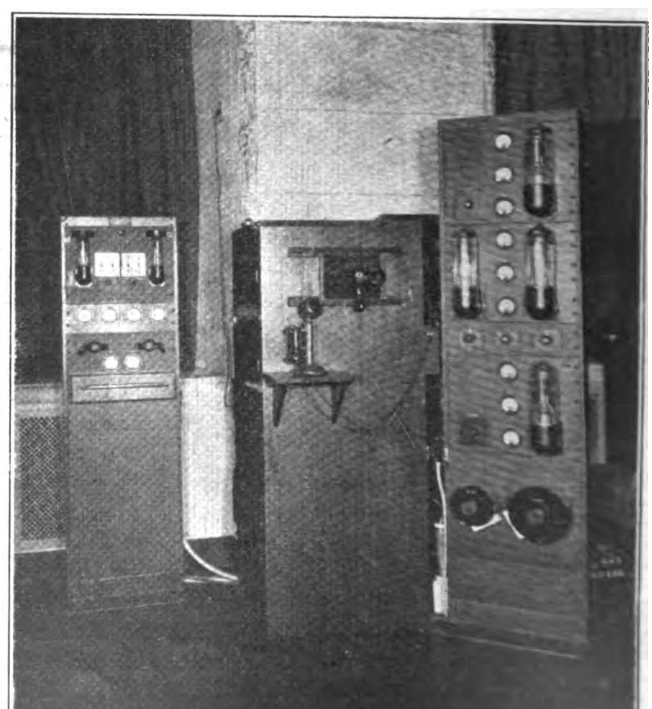


RIGHT.—*The engine room of the "Locomotor" shown above. At the right may be seen the engineer's compartment, and at the extreme right the boiler casing.*

ABOVE.—*A life-size restoration of the armored dinosaur Stegosaurus Stenops Marsh in the United States National Museum. This creature which lived in the Jurassic of the Rocky Mountain region reached a length of twenty feet and a maximum height of almost twelve feet. The model from which this restoration was made is now on exhibition at the Peabody Museum.*

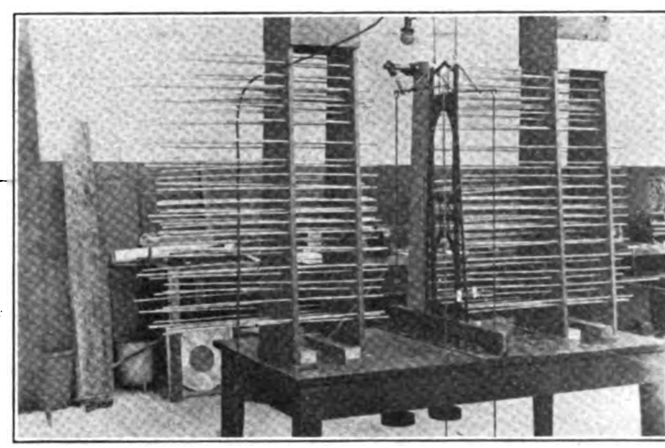
LOWER LEFT.—*Complete color television transmitting equipment developed by the Bell Telephone Laboratories. Color television, in essence, consists of the transmission of three monochromatic images of the moving object. In the open cabinet at the right are the arc light and the associated equipment used to illuminate the subject. At the left of this is the scanning disk, which causes a narrow beam of light from the arc to travel back and forth over the face of the subject. The girl is facing a battery of 24 photoelectric cells each of which transmits a current proportional to the amount of one of the primary colors—red, blue or green. The rear connections of ten of these cells are shown.*

BELOW.—*The complete receiving and apparatus showing the synchronizing panel at the left and the amplifiers for the three channels at the right. In the center is the cabinet containing the scanning disk, three lamps and color filters.*

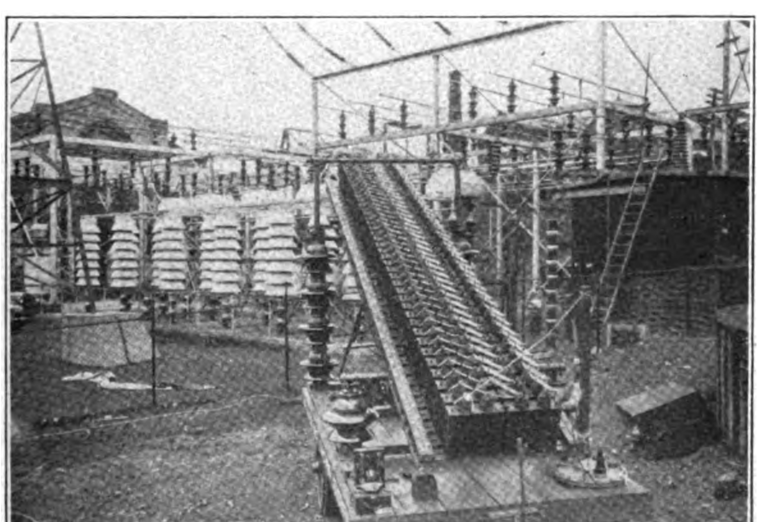


ABOVE.—*The proposed Liberty Bridge over the Narrows at New York City to connect Staten Island with Brooklyn. The span length of 4,500 feet will exceed that of the well-known Hudson River Bridge by 1,000 feet. The towers supporting the two four-foot cables will be 800 feet in height.*

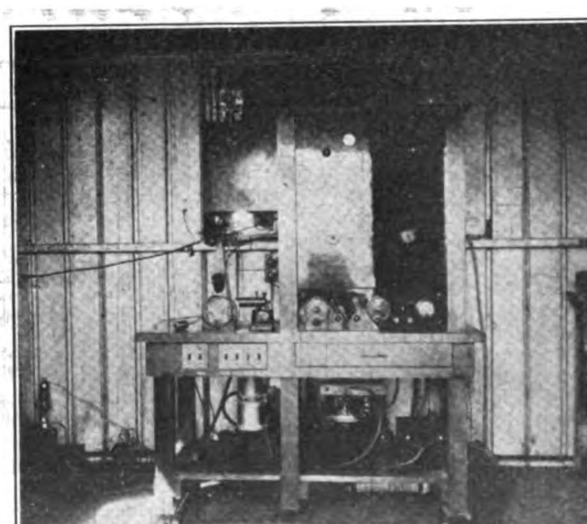
RIGHT.—*Professor C. F. Scott, Chairman of the Department of Electrical Engineering of Yale who has recently been awarded the Thomas A. Edison medal of the American Institute of Electrical Engineers "for his contributions to the science and art of polyphase transmission of electrical energy." Previous to his appointment to his present position, Professor Scott, connected with the Westinghouse Company, was a pioneer in the fields of high voltage transmission of power and in the development of several types of induction motors and transformers. He developed the "Scott" transformer connection in 1894. Its purpose is the transformation from two-phase to three-phase or vice-versa. He was the first to investigate corona losses in high tension transmission lines.*



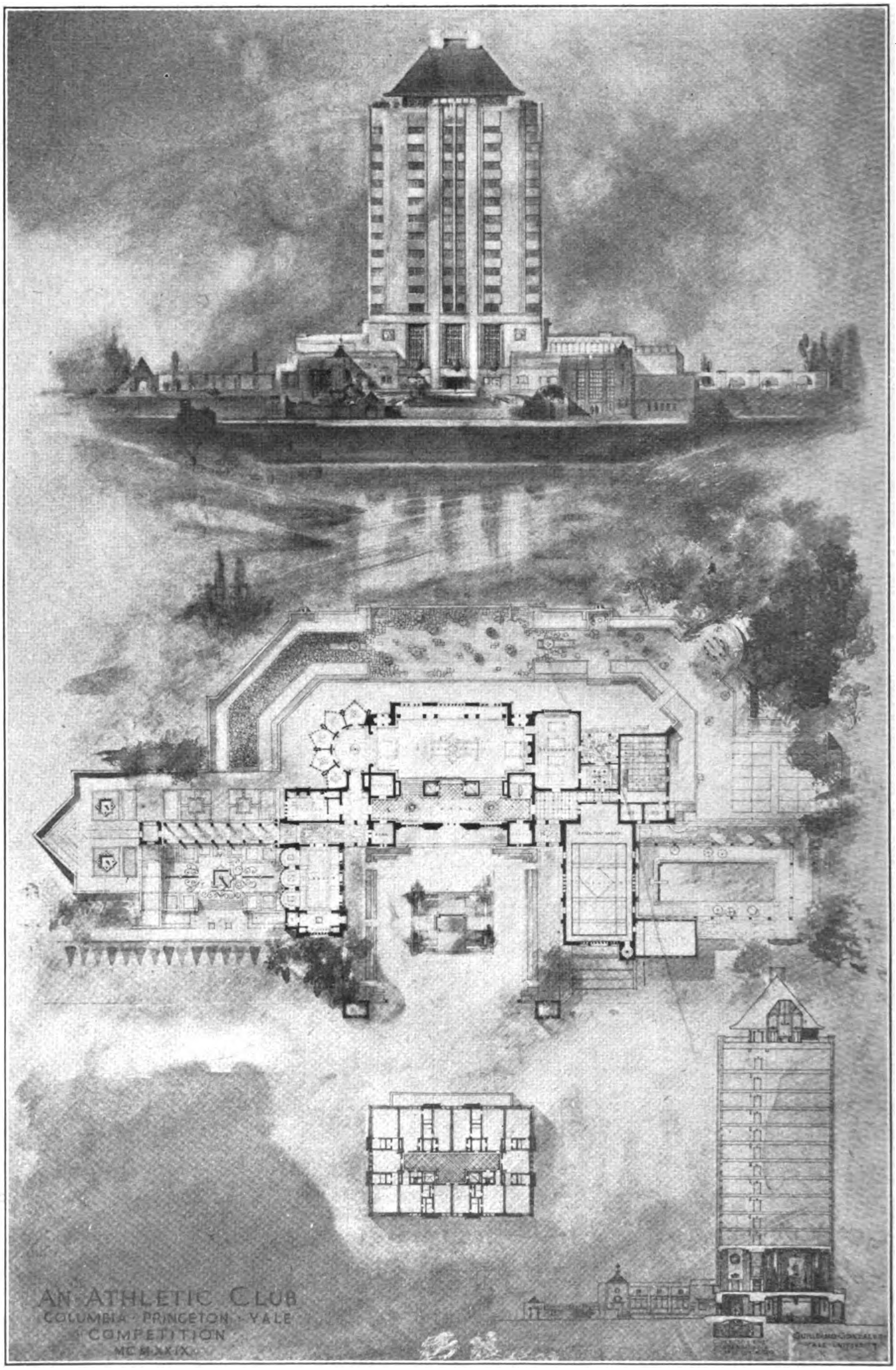
ABOVE.—*An elastic model of a tower for the St. Johns Bridge, Portland, Oregon being tested to determine the characteristics of this design of pier. This bridge, like the Liberty Bridge was designed by Robinson and Steinman.*



ABOVE.—*A million-volt portable impulse generator built by the General Electric Company for studying surges on transmission lines. It is here shown set up for tests in a substation.*

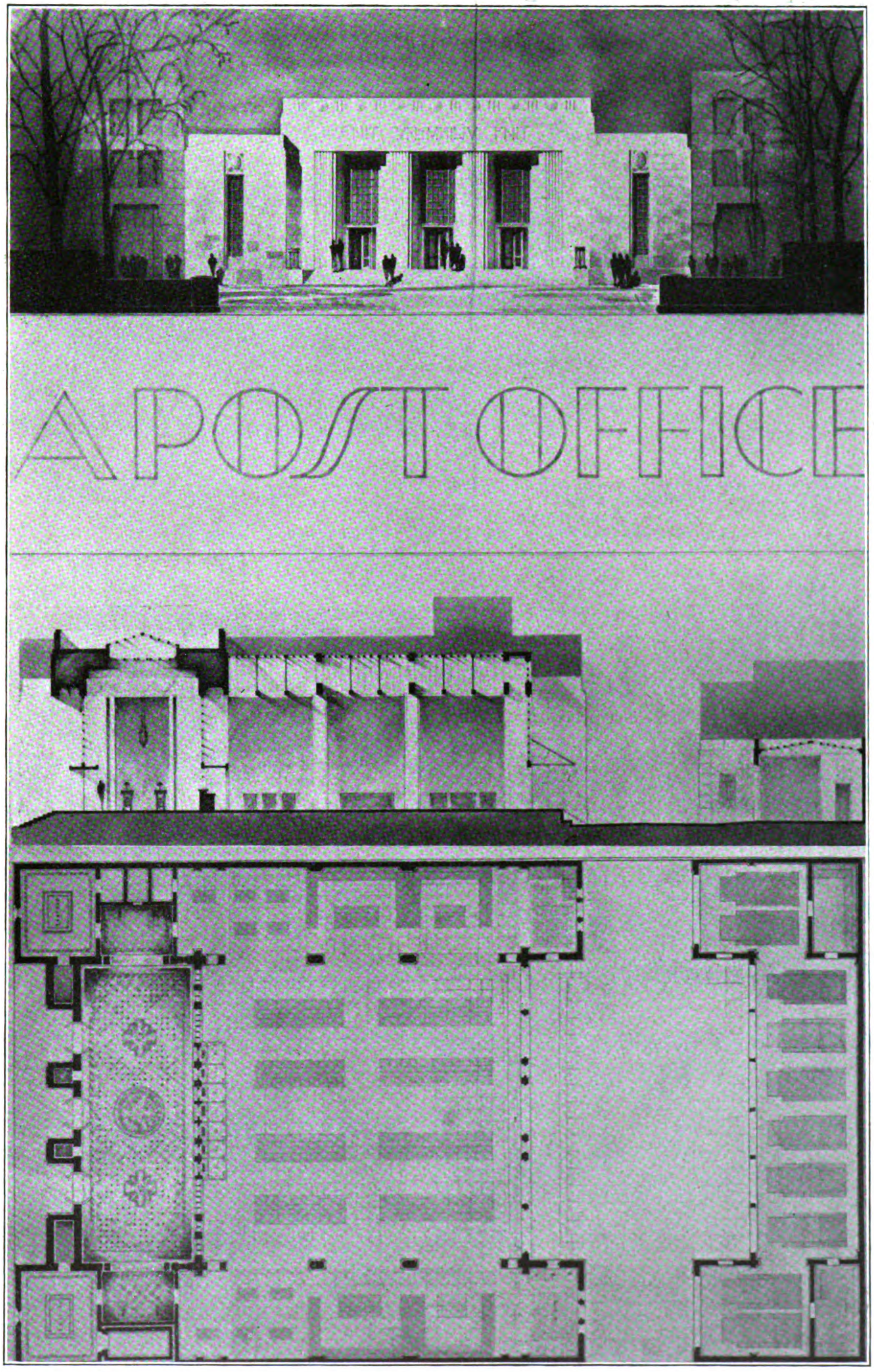


RIGHT.—*A hot-cathode-ray oscillograph of the type developed by R. H. George of Purdue University set up for calibrating and recording the effects of the surges set up by the impulse ligning generator shown above.*



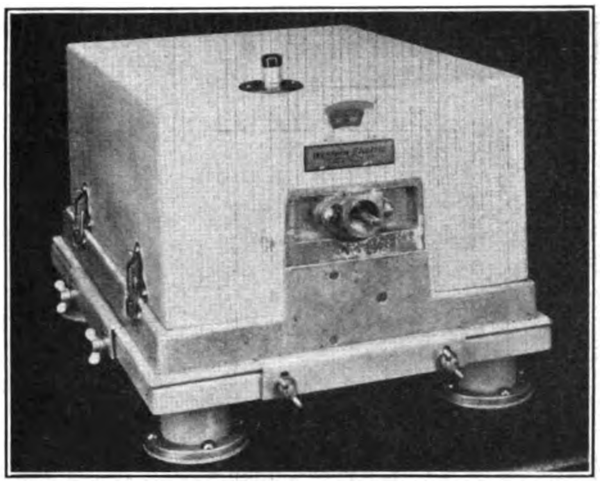
"AN ATHLETIC CLUB"

By Guillermo Gonzales, Yale School of Architecture, First Medal, Columbia-Princeton-Yale Competition 1929-1930.



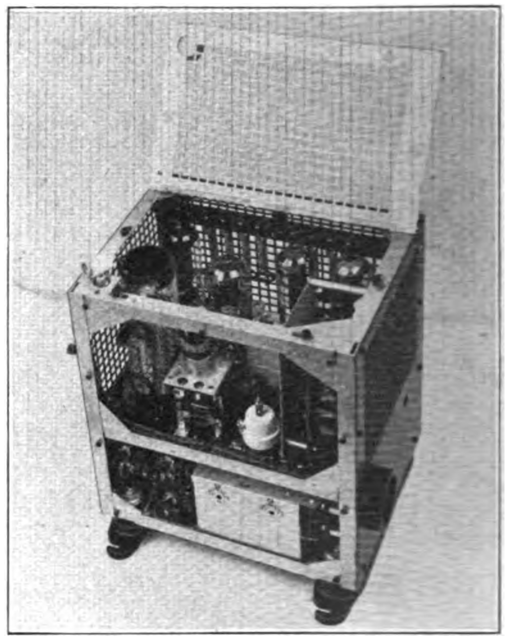
"A POST OFFICE"

By C. L. V. Meeks, Yale School of Architecture, First Mention placed, class B-1 Project, Beaux-Arts Institute of Design.

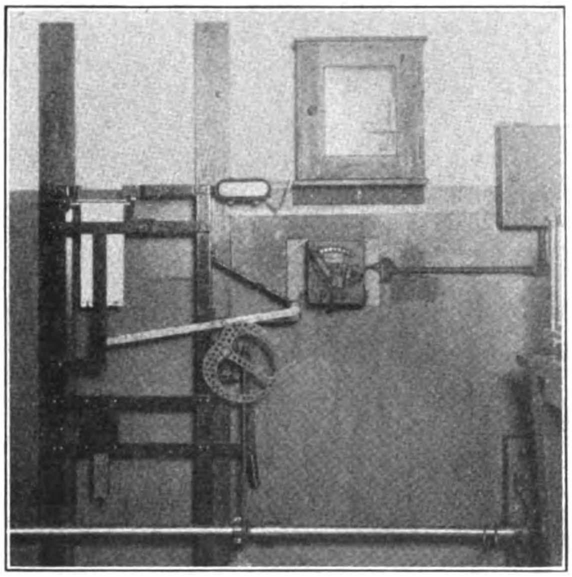


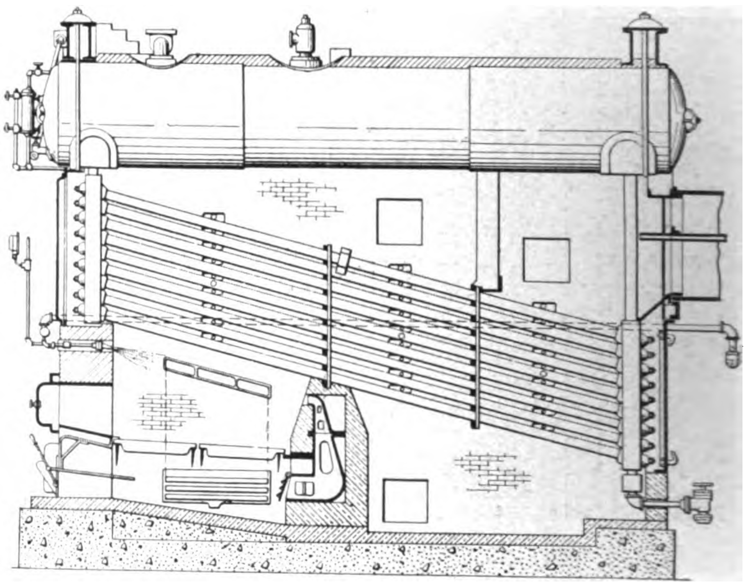
RIGHT.—This Radio telephone Transmitter with its associated 9-B receiver developed for aviation service by the Western Electric Company provides direct radiotelephone facilities between planes in flight and ground stations. The transmitter may be adjusted to any frequency between 1,500 and 6,000 kilocycles (200 to 50 meters). Two 5 watt and four 50 watt vacuum tubes are installed in the transmitter.

LEFT.—The Western Electric Radio Telephone Receiver like its associated transmitter is designed to be installed wherever convenient, with volume and tuning from remote controls placed in any desired location in the plane. A dynamotor operated by a twelve volt plate battery which also supplies current for the filaments of the tubes is used to supply plate current to the receiver.

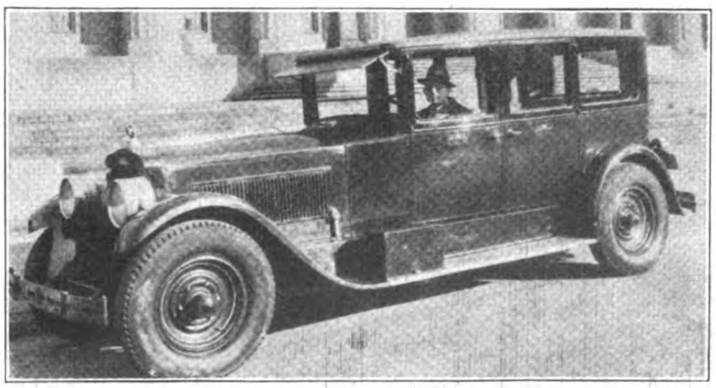


BELOW.—A fabric testing machine developed by the Textile Research Department of the Massachusetts Institute of Technology. The fabric is flexed over a small roller and, at the same time the surface of the material is worn by contact with a standard abradant. The number of abrasive strokes is counted. The reduction in tensile strength after a given number of strokes, when expressed in terms of the original strength is a measure of the abrasive resistance of the material.



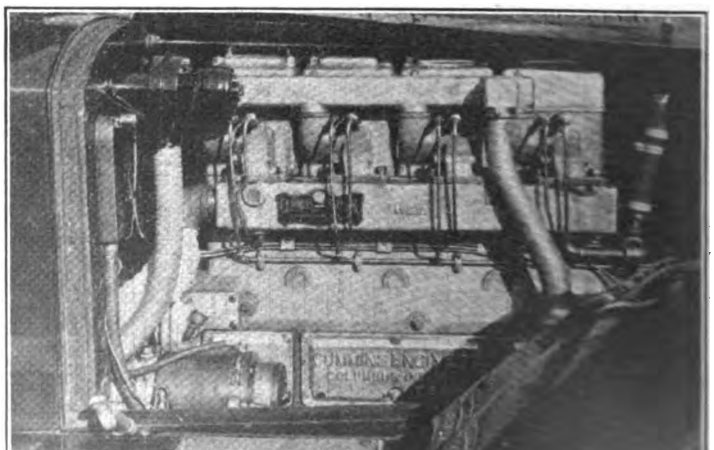


ABOVE.—The device shown is for the purpose of eliminating the smoke of steam boilers through more perfect combustion in the furnace. Preheated air is forced in through fan-shaped jets located above the fuel bed around the walls increasing the turbulence of the gasses over the fire. The amount of air admitted at these jets—there are two generally—is controlled by louvered openings below the grate, the position of the louvers being controlled from the front of the boiler as shown. The device, known as the Luks Smoke Carburetor, becomes an integral part of the furnace.



ABOVE.—This car is one of the first to be experimentally equipped with a Diesel engine. The Cummins Diesel installed has four cylinders 4½" x 6". The transmission and the differential used with the gasoline engine formerly installed in the car were used unchanged except to alter the differential gear ratio slightly. A maximum speed of 55 miles per hour is attained. The fuel cost per mile is about one fifteenth that of the gasoline engine formerly used.

RIGHT.—The engine in place in the car.



THE DNEIPER RIVER HYDROELECTRIC AND NAVIGATION PROJECT.

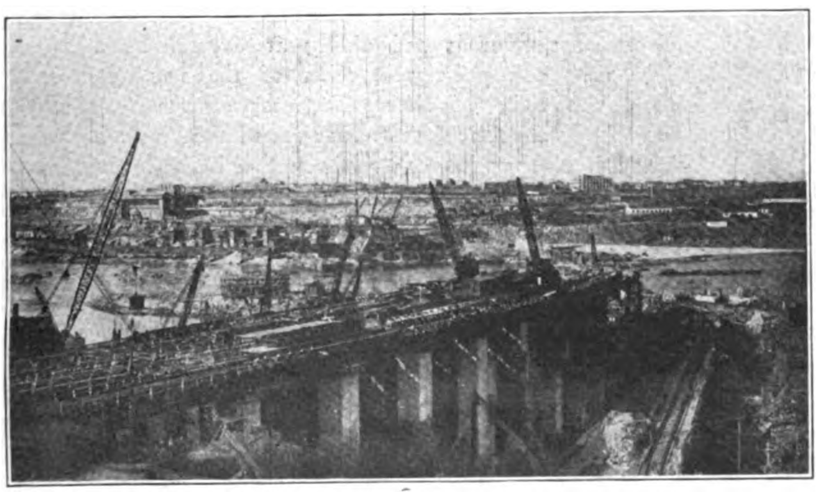
The Dneiper River project when completed in 1934 will be the center of a vast super-power system for the support of existing and future industries within a radius of 300 miles of Kichkas. The area served will be about 70,000 square miles. The saving on coal due to the use of hydro-electric power from the Kichkas power station will be about 3,000,000 tons annually. The project is being financed and built by the Government of the U. SS. R.

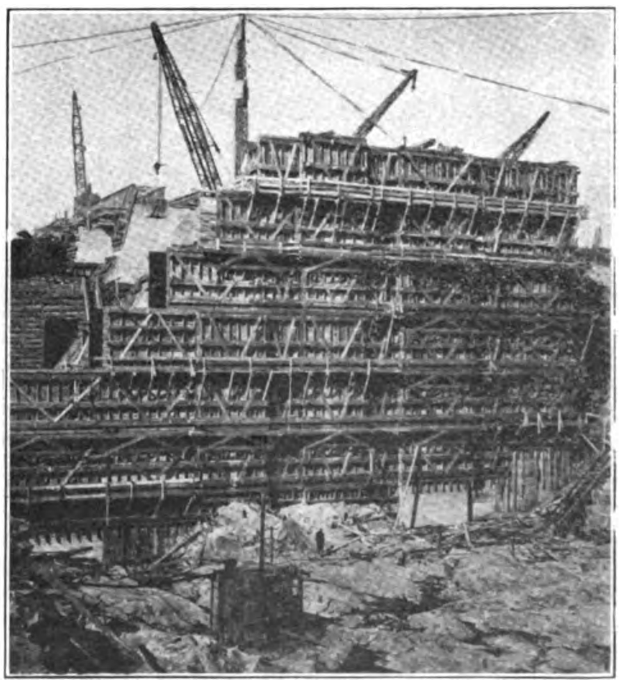
BELOW.—*The excavation for the power house where the nine generators totalling 750,000 horse-power will ultimately be installed. The initial installation is 330,000 horsepower.*

ABOVE.—*A view looking downstream at the excavation for the upper lock chamber.*

RIGHT.—*The forms for one of the piers of the dam in place. The top of the dam is to be at the level of the sign halfway up the mast of the crane in the background. The operating head is to be 116 feet.*

BELOW.—*A recent view of the entire project looking towards the right bank, showing the method of construction from both banks of the river. 1,500,000 cubic yards of concrete will be used in the completed project, for which Hugh L. Cooper and Co. of New York are the consulting engineers.*





Yale Engineering Association News

YALE ENGINEERING ASSOCIATION

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"EVERY MEMBER GET A MEMBER".

THE Annual Meeting of the Yale Engineering Association, which occurs in March is the focal point of the year for the annual membership effort. When we realize that there is something over eight thousand men of Yale engaged in occupations where engineering and science play an important part, who are not yet members of the Yale Engineering Association, there is good reason for the heading of this item. If every member of the Yale Engineering Association would resolve now to secure one additional member each, it is self evident that we would double our membership within thirty (30) days. This would give us the weight of numbers in our membership to help Yale strengthen its Scientific School, Sheff.

Recognizing the Yale Scientific Magazine as one of the finest features of the Yale Engineering Association membership and one of the most recent noteworthy activities of Yale men in Sheff, both graduates and non-graduates, the Membership Committee of the Yale Engineering Association, made up the attractive four page folder from the November issue of the Yale Scientific Magazine. This was mailed to everyone of the 8000 men of Yale who should be members of the Yale Engineering Association.

In this circular it was emphasized that the man who has left Yale does not have to be in engineering work to become a member of this organization. It is hoped that every reader of the Yale Scientific Magazine, both graduate or non-graduate, whenever they come in contact with a Yale man who is not a member of the Yale Engineering Association, that they will talk membership to him and secure that membership and send it into the Secretary-Treasurer. The New Year Book of the Association contains a few convenient application forms. Examine the Year Book from cover to cover and if the names of your associates, acquaintances or Yale men that you know, are not in that membership list, adopt the necessary routine of a personal call, definite message or letter or telegram, to obtain their membership.

PRINCETON ENGINEERING ASSOCIATION IS HOST AT JOINT HUDDLE.

THE Princeton Engineering Association, hosts this year at the annual H-Y-P meeting, entertained with a special program at the Westinghouse Lighting Institute which occupies an entire floor of the Grand Central Palace in New York City. The auditorium was entirely filled when the master of ceremonies introduced Mr. Walter Carey, Harvard '93 who, as president of the Westinghouse Lamp Company, welcomed the assemblage to "Mazda City." The presidents of the two Associations and the Society next brought the greetings of those they represented to the others and expressed their satisfaction with the spirit of cooperation and friendship which these meetings symbolize—William Elmer, '92, for Princeton; Calvert Townley, '86, for Yale; and Theodore R. Kendall, '12, for Harvard.

The aims and activities of the Institute were discussed by Mr. Ralph Neumiller, its director. Here, he explained, the latest and most approved solution of almost any lighting problem may be found and studied. Classes, open to all interested, are conducted and engineering services are freely rendered. The "City of Light" is intended to be a center of information to the general public. Regular tours through the many exhibits are conducted at intervals throughout the day by special guides. While Mr. Neumiller was speaking, the rich effects obtainable in the auditorium with colored lights were demonstrated. His remarks were concluded with a remarkable moving picture of underwater swimming and diving at Crystal Lake, Florida.

The next and principal speaker of the evening was Mr. Samuel G. Hibben, Lighting Engineer of the Westinghouse Lamp Works in New Jersey. He stated that we are just beginning to realize what can be done with light; in fact we are just beginning to see. Color is that property of a surface which causes it to reflect light of certain wave lengths and not to reflect light of other wave lengths. If the light source does not contain the wave lengths which the surface can reflect it appears colorless to our eyes. Under one type of lighting a designed wall paper or fabric may reflect brilliant red, yellow or green, while if the light source is changed these colors may be replaced by others equally rich but wholly contrasting.

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P·E·R·S·O·N·A·L·I·T·I·E·S

EGBERT J. MILES.

A CERTAIN distinguished author, himself a Hoosier expatriate, is supposed to have remarked, "Lots of good men come from Indiana, and the better they are the sooner they come". That this statement is true is so obvious that the proof may be safely left, as the textbooks say, to the reader. It is mentioned simply because the career of Professor Egbert J. Miles seems to mark him as one of those to whom the distinguished author referred.

Professor Miles does not hail from the Banks of the Wabash, as one might expect, but from those of the Ohio. He was born in Clark County in 1886 and the first sixteen years of his life were spent on his father's farm. In the fall of 1902 he entered Indiana University where he fell under the influence of a particularly virile type of pedagogy. If Freshman Miles transposed a term from one side of an equation to the other without changing the sign he was admonished by having a piece of chalk flung at him. For more serious offences, such as dividing by zero, a dusty eraser was substituted for the chalk. But it was good training and he learned. As an upperclassman he was rarely the target of the correcting missile.

In his senior year he decided to become a mathematician and with great faithfulness he has followed that career to this day. He received his degree from Indiana in 1906 and three out of his next four years were spent in the graduate school of the University of Chicago. There he had the privilege of attending the lectures of Oscar Bolza and it was under him that he wrote his dissertation in 1910. It was entitled "The Absolute Minimum of a Definite Integral in a Special Field" and dealt with a problem in the Calculus of Variations.

After a year at Cornell, Miles was appointed instructor in mathematics in the Sheffield Scientific School. He served on that faculty until 1920 when he was assigned to the newly formed Freshman Year. This change, however, was nominal in a sense for it in no way affected the deep interest which he had developed in his original assignment. Among the points of contact which he maintains might be mentioned his membership in the Torch Honor Society, the Berzelius Society and Sigma Xi.

In regard to original research Professor Miles has done his work principally in the field of the Calculus of Variations and has published a number of papers on that subject. In recent years he has devoted himself to preparing a course in mathematics designed to cover the first three years of college work. It is understood that Professor Miles has treated a number of topics from an original point of view and the appearance of these volumes is awaited with interest by those who are acquainted with his success as an instructor.

To those students whose good fortune it has been to sit in Professor Miles' classes, either through blind chance as freshmen, or through choice as upperclassmen, he is always outstanding as a teacher. His success can be attributed primarily, to his having acquired, to an extent which few are able to rival, the ability of rivetting the attention of his hearers to the subject at hand. This he does, by fair means or foul, but principally by the expenditure of an enormous amount of his own energy with which he bombards the senses of his audience. When, for example, he comes to a difficult point such as that in the freshman course where he must convince the student that $\frac{\Delta y}{\Delta x}$ approaches the derivative and not utter nonsense, he does not hesitate to use physical as well as mental tactics. Those who have experienced it will admit that it is sound pedagogy.

Shortly after his first appointment at Yale Professor Miles married Miss Helen Hanson, a graduate of Vassar. The story goes that Mrs. Miles once gave a singular proof of her devotion by sitting through an entire session of the American Mathematical Society, an ordeal which members of the Society themselves do not contemplate too happily.

Professor Miles has one hobby, or perhaps it would be better to say three. His hobbies are his three sons, Egbert J., Richard Curtis, Philip Giltner. At the first suggestion this might seem

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Chemistry

Professor Kasimir Fajans of the University of Munich visited the Sterling Laboratory on February 7th and delivered a lecture before the Faculty and Graduate students. Professor Fajans, who has won international recognition for his investigations on solutions, radioactive substances, and atomic structure, is non-resident lecturer on the Baker Foundation at Cornell University this semester.

A large number of the departmental faculty and graduate students attended the 3rd National Organic Chemistry Symposium, of the American Chemical Society which was held at Princeton University, December 30th to January 1st.

The next biennial organic symposium will be held at Yale during the latter part of December, 1931.

The following scientists have accepted invitations to address the departmental seminar: Professor A. D. Hirschfelder of the University of Minnesota, February 19th, Dr. Horace Shonte of the Eli Lilly Company, February 26th, and Professor William Evans, of Ohio State University, March 4th.

Forestry

Approximately 20 alumni and guests attended the Third Decennial Reunion of the Yale Forest Alumni Association on February 21st to 22nd. Among the speakers for the occasion were President Angell; Gifford Pinchot, former Governor of Pennsylvania and Chief Forester of the U. S., who was instrumental in organizing the School of Forestry; Robert Y. Stuart, present Chief of the U. S. Forest Service; Samuel N. Spring, Professor of Silviculture at Cornell University; and Emanuel Fritz, Associate Professor of Forestry at the University of California.

Announcement has recently been made of three new gifts to the School of Forestry to be devoted to education, experiment and demonstration in applied forestry. The Charles Lathrop Pack Foundation given last year by Mr. Charles Lathrop Pack of Lakewood, New Jersey, has been increased to $325,000. A gift of $100,000 to endowment has been received from Mr. and Mrs. Starling W. Childs of New York. Mr. George Hewitt Myers of Washington is transferring to the School a tract of forest land in Tolland and Windham Counties, Con-

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Geology

Professor Bateman has been working up material gathered in Rhodesia this last summer. He delivered a paper on this subject before the Canadian Mining Institute at its annual meeting in Toronto in March and a lecture at the University of Toronto. He gave a paper before the American Institute of Mining Engineers at their annual meeting in New York in February on Geology and Geophysical Prospecting, and will give a paper before the Society of Economic Geologists in April.

The Department of Geology this year has twenty graduate students pursuing geological studies, of whom 12 are pursuing work leading toward the degree of Ph.D. and the remainder the Master's degree. One of the Commonwealth Fellows, W. L. S. Fleming, is also studying in the department.

Professor Longwell on February 12, addressed the Geological Society of Washington, in Washington, D. C., on the subject "Some Problems of Mountain Structure and Mountain History."

Professor Flint has been engaged recently on geologic investigation for the State of Connecticut involving problems of water-supply. His detailed study of the *Glacial Geology of Connecticut*, prepared as Bulletin 47 of the Connecticut Geological Survey, is now in press and will be ready for distribution in the spring, together with a detailed map showing all the glacial deposits in the State.

Professor Flint's discussion of the classification of glacial deposits will appear in the May number of the *American Journal of Science*. *The Geographical Review* will publish in its July number his study of the origin of the Irish "eskers". The latter study grew out of a visit to Ireland in 1929 on the Dana Research Fund.

Professor Adolph Knopf has recently published in *Economic Geology* a paper on "The Engels Cooper Deposits, California."

Mining and Metallurgy

Professor Mathewson will present a paper on "Directed Stress in Copper Crystals" before the annual meeting of the A. I. M. M. E. to be held in New York February 17th to 20th.

A series of motion picture exhibitions depicting industrial operations in the mining, milling and smelting of copper and iron, and the heat treatment of steel,

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Biology

The staff and students, including many former students, of the Osborn Zoological Laboratory at Yale University, on January 13 celebrated the sixtieth birthday of Dr. Ross G. Harrison, Sterling professor of biology and director of the laboratory. During the afternoon a reception for Dr. Harrison was held in the building, at which a handsome watch, appropriately inscribed, was presented to him on behalf of the staff and students by Professor W. R. Coe, senior member of the departmental faculty. Dr. S. R. Detwiler, professor of anatomy at Columbia University, one of Professor Harrison's early students, presented to him the current volume of the JOURNAL OF EXPERIMENTAL ZOOLOGY, entirely composed of contributions by Dr. Harrison's students and prefaced by his portrait. Later an informal dinner was held at the Faculty Club. In addition to congratulatory telegrams and letters from many individual biologists at home and abroad, Dr. Harrison received felicitations from the Statione Zoologica at Naples, the Kaiser-Wilhelm Institut fur Biologie at Berlin and the Medical Faculty of the University of Bonn where he received the degree of M.D. thirty years ago. The University of Freiburg conferred upon him the honorary doctorate of philosophy.

Medicine

Dr. Eugen Kahn of Munich has been appointed Professor of Psychiatry and Mental Hygiene in the School of Medicine. Dr. Kahn is among the first to be appointed in connection with the development of the program of study in psychiatry and mental hygiene in the Yale University School of Medicine.

New appointments to the faculty of Yale University with assignment to the School of Medicine include the following:

John William Spies, M. D., Surgical Pathology; Chester M. Van Allen, M. D., Surgery; Konstantin Lowenberg, M.D., Neuropathology; Frederick Mandeville, M.D., Radiology; John Kenneth Deegan, M.D., Clinical Instructor in Medicine.

Frances Baird, B. A., Alice G. Howard, B. N., and Clara M. Brown, B. S., have received appointments in the School of Nursing.

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Industrial Engineering

Professors Hastings and Smith have been appointed to the staff of the Institute of Human Relations. As stated in a recent bulletin, there are now brought together through representation on the staff of the Institute of Human Relations the various units centering around the Yale Medical School, and the—

Graduate School of Yale University
Yale School of Law
Yale Divinity School
Department of Industrial Engineering

The Reading Room of the Department, which was established last year, now contains over 200 volumes divided among the following fields: Biography, Economics, Education, Government, History and Travel, Industrial Relations, Literature, Philosophy and Religion, Psychology, Science, and Sociology. The major part of this library was contributed by alumni who are interested in the effort of the Department to widen the background and range of interests of our students. All students in the Department are encouraged to read books from this library, and in addition, ten men from each Class are selected to receive special instruction and guidance in their outside reading.

There are six students enrolled this year for graduate study in Personal Problems.

Professor Smith has recently been appointed a member of the Advisory Committee on Industrial Relations of the National Industrial Conference Board, and also a member of the Committee on Instruction in Industrial Relations of the Society for the Promotion of Engineering Education.

On January 31, Professor Smith delivered a paper on "What are the Psychological Factors of Obsolescence of Workers in Middle Age" before a meeting of the American Management Association in Cleveland.

Professor Hastings attended the annual meetings of the Taylor Society in New York in December and served as Chairman of the Resolutions Committee.

At the annual meeting of the State Industrial Council of the Y. M. C. A. Professor Hastings was re-elected Chairman. This Council sponsors educational, recreational and inspirational activities for craftsmen, supervisors, and executives in the industrial centers of Connecticut, and also conducts an annual State Industrial Conference at Camp Hazen. Two hundred and forty-seven industrial delegates attended the last conference.

Mechanical Engineering

Practically all of the staff of the Department of Mechanical Engineering and most of the graduate students attended some of the sessions of the Annual Meeting of the American Society of Mechanical Engineers in New York City, December 6th to 10th. Professor E. O. Waters, Chairman of the New Haven Section, was an official delegate to the Local Sections Conference, which convened on Saturday evening, December 4. Professor Dudley was Chairman of the Meetings and Program Committee in charge of the arrangements for this Annual Meeting.

Professor S. W. Dudley has been made Chairman of the Executive Committee to arrange for the 50th Anniversary Celebration of the American Society of Mechanical Engineers, to be held at New York City, Hoboken, N. J., and Washington, D. C., April 5th, to 9th, inclusive.

On February 11, 1930 Professor Waters attended a meeting of the American Society of Mechanical Engineers, held in

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Civil Engineering

Professor C. T. Bishop has been appointed by Mayor Tully a member of the New Haven Board of Park Commissioners. He was recently elected Alderman on the Republican ticket from the 30th ward (Westville).

Professors Tracy, Bishop and Suttie attended the annual meeting of the American Society of Civil Engineers in New York in January.

On January 31st, members of the department and their wives were entertained by Professor and Mrs. Suttie at their new home on Mill Rock Road. Professor Tracy's graphic story of his fourteen-thousand mile motor trip was the feature of the evening.

Professor Kirby read a paper February 18 at the annual meeting of the Connecticut Society of Civil Engineers on "Some Early American Civil Engineers."

Professor Tracy and Bishop attended the joint smoker of the Yale-Harvard-Princeton engineering associations held in New York recently.

Two recent lectures under the auspices of the Yale University Student Chapter of the A. S. C. E. have been of more than ordinary interest. Mr. Billings Wilson ('16s), Deputy Manager, the Port of New York Authority, spoke November

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Electrical Engineering

Professor R. G. Warner has been appointed Electrical Engineer of the Public Utilities Commission of Connecticut. This is a position which has been held by Professor Knowlton for many years. He resigned on account of his present leave of absence for the remainder of the year.

The electrical engineer is the technical adviser of the Commission with regard to rules which it may adopt covering various practices of the electric power and telephone companies, also gas, water and electric railway companies. There are also constantly arising particular cases some involving the interpretation of the rules, others requiring modifications with the development of the art. In general, installation of new transmission lines as regards the type of construction, are passed upon by the electrical engineer. The testing of the measuring appliances is under his supervision. The electrical testing equipment, involving special generators and refined standard measuring instruments, is located in the Dunham Laboratory. The standard meters including the watthour meters which are the basis of the bills rendered by the operating companies of the State are periodically sent to the Dunham Laboratory for comparison with the State's standard. Graduate students assist in the calibration of these instruments.

While many of the rulings of the Commission refer to the work of individual companies, it also supervises and directs the cases in which the interests of different companies are involved in the same situations such, for example, as the joint use of poles by the power and telephone companies.

From time to time certain inspections are made of the various properties. These inspections for the convenience of the engineer are usually made during the vacation periods.

Professor Knowlton's work with the Commission began with the beginning of the Commission itself some twenty years ago when he was connected with Trinity College in Hartford. The development of the electrical policies and rules were largely due to Professor Knowlton's intelligent and painstaking efforts. The relations with the Connecticut Commission brought him in contact with National committees and the Bureau of Standards for consultation on matters of electrical practice and standardization.

FORESTRY

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necticut, aggregating in area nearly 8,000 acres. These gifts, all closely related in purpose, constitute a new project, supplementing and greatly strengthening the work and facilities of the School of Forestry in instruction and in advancing the knowledge and practice of forestry. Announcement is also made of the appointment of Mr. Nathan D. Canterbury, '22 F., formerly State Forester of Louisiana, as Director of the new Yale Forest, on the Charles Lathrop Pack Foundation.

The gift to Yale for the establishment of the Charles Lathrop Pack Foundation is only one of Mr. Pack's contributions to the advancement of forestry. He has previously aided the Yale School of Forestry, and he has given funds to a number of other schools of forestry. The income from the Pack Foundation at Yale will be used in part for work on the new forest, in part for investigative work in features of applied forestry, and in part for coöperative and general educational work among forest owners.

Mr. Childs, a graduate of Yale in the Class of 1891, and Mrs. Childs, who are contributing to the new forestry enterprise, have already interested themselves on the work at the Yale Natural Preserve and are largely responsible for the assembling of an endowment of $30,000 for that special project. The Natural Preserve is a tract of 200 acres located near the Yale Golf Links and used for scientific purposes by the Departments of Forestry, Botany, and Zoology. Mr. and Mrs. Childs have also given large support to the Yale Library and to other University enterprises.

Mr. Myers is a graduate of Yale College in the Class of 1898 and of the Forest School in its first class in 1902. In 1913 Mr. Myers gave to Yale his forest land at Keene, New Hampshire, which has been developed into one of the most important research and demonstration forests in the country. Mr. Myers has made other contributions of importance in connection with the Forest School library and laboratories. He is well known as a collector of rare rugs and other textiles, and has recently been appointed Curator of Textiles in Yale University's Gallery of Fine Arts.

Announcement has also been made of the establishment of a scholarship fund of $20,000 in the School, by the will of the late Antoinette Eno Wood of Simsbury. The scholarships, which are to be known as The Charles Broughton Wood Scholarships, will be awarded for the first time next fall.

The annual spring field work for the Senior class will be conducted from about March 15th to June 6th on the Hardtner Forest at Urania, La., and the lands of the Crossett Lumber Co., at Crossett, Ark. The camp will be in charge of Professors Chapman and Bryant and about 20 men will be in attendance.

MECHANICAL ENGINEERING

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New York City, under the auspices of the Aeronautics Division of the Society. In the afternoon there was an inspection trip to the Curtiss plant at Garden City, L. I., at which the guests had an opportunity to see one of the largest American wind tunnels in operation, and observe the methods used by the Curtiss Company in building various types of aircraft, in particular, the Hawk and Condor models.

The trip was followed in the evening by a dinner at the Engineers Club in honor of Dr. Ludwig Prandtl of Göttingen University, one of the world's leading aerodynamicists, now visiting the country. Mr. Elmer Sperry, past president of the Society, introduced the guest of honor in a brief but very graceful speech.

After the dinner came a technical meeting in the adjoining Engineering building, with two papers, the first one by Mr. Moore of the Wright Aeronautical Corporation on materials used in airplane engines, and the second by Dr. Prandtl, on the formation of vortices. This highly technical subject was made extremely lucid and interesting by Dr. Prandtl's careful manner of presentation, and his lantern slides and film which showed, by means of particles of aluminum powder moving on the surface of water, the actual creation and growth of vortices around typical wing sections and the other shapes. Incidentally, the effect of slots on vortex formation was exhibited in no uncertain manner.

The undergraduate members of the class in Marine Engineering accompanied Professor Seward on a series of trips on Long Island Sound Steamers during the midyear examination period. Data was collected on different types of power plants and operating conditions noted. One day was spent on Pennsylvania R. R. Co. Diesel Electric Tug No. 16 in the Port of New York when the maneuverability of this new form of propulsion was observed and terminal facilities in the harbor were inspected. The graduate members of the class took positions as oilers on coastwise steamers and had the benefit of about two weeks' practical work under operating conditions.

Professor Seeley attended a meeting of the American Society of Heating and Ventilating Engineers, January 27-31, 1930, held at the Benjamin Franklin Hotel, Philadelphia, Pa., and the Heating and Ventilating Exposition.

Inspection trips were made by students taking M.E.24, Industrial Management, accompanied by Mr. P. B. Brill, as follows: January 13, to the plant of the New Haven Clock Company, making a general inspection of shops; an interesting explanation of the policies and methods of operation and control was given by Mr. Burham; January 14, to the Rockbestos Manufacturing Company in order to observe the manufacture of asbestos insulated electric cables. Many highly developed special machines were noted, as well as an interesting system of piece work.

Professor E. O. Waters attended a National Conference on Aeronautical Education, held in St. Louis, Mo., February 17, 18, and 19, under the auspices of the Educational Committee of the Aeronautical Chamber of America, Inc., 10 East 40th Street, New York City. This conference was of importance in determining fundamental trends in educational programs dealing with aeronautical laboratory and course work, and was rendered doubly interesting because the International Aircraft Exposition was held in St. Louis from February 15 to 23.

Professor L. C. Lichty attended the Annual Meeting of the Society of Automotive Engineers, held at the Book-Cadillac Hotel, Detroit, Michigan, from January 20 to 24, 1930. While there, he visited the plant of the Continental Motors Company, aircraft engines division, in which a former student, George L. Kreider, '29S is employed. He also visited the engine department of the Ethyl Gasoline Company, which is located in Detroit, as well as one of the larger power plants of the Detroit Edison Company, where G. G. Halfinger and J. L. Bannoff, both '29S are employed.

Mason F. Smith, Research Assistant in Mechanical Engineering, has been cooperating with Mr. Robbins B. Stoeckel, Commissioner of Motor Vehicles of the State of Connecticut, in the formulation of a test program for specifications of approved types of rear-end reflector signals for use on motor trucks, motor busses, etc. During the fall and winter months a total of 25 forms of these devices offered by 11 companies have been tested and certified to the State Department of Motor Vehicles, as satisfying the requirements of their specifications.

Shortly after Christmas, E. H. Lockwood suffered an attack of acute indigestion which developed a rather serious heart condition, which has kept him confined to his home ever since. It is a great satisfaction to be able to see that he has made encouraging progress since the first of the year. He is able to get around his

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HENRY ANDREWS BUMSTEAD, 1870-1920

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for his title "Present Tendencies in Theoretical Physics." In 1913 he was elected a member of the National Academy of Sciences, the highest honor which can come to any scientist from an American institution. He was a fellow of the American Academy of Arts and Sciences, and a member of the American Philosophical Society and of the Connecticut Academy of Arts and Sciences. The University of Toronto conferred on him the honorary degree of Doctor of Science the June preceding his death.

Not only was Bumstead's advice always in demand on the part of his scientific confrères, but it was frequently sought by those whose chief interests lay along the lines of the so-called humanities. As an example may be cited Henry Adams' request for a critical opinion of those chapters of "The Degradation of the Democratic Dogma" which contained the author's bold excursion on the scientific method. Bumstead pointed out the dimensional difficulties involved in applying the "law of squares" to historical phases, and repeated his criticism to Brooks Adams when the latter was preparing his brother's manuscript for publication. In this instance, however, science lost that history might be justified.

With the entrance of the United States into the World War, Bumstead placed all his time and ability at the service of his country. He was a member of the national committee appointed to examine the merits of proposed anti-submarine devices, and he took an active interest in the experimental development of such devices which was carried on at New London. In February, 1918, he went to London as Scientific Attaché of the American Embassy. There has tact and wide acquaintance among men of science in Great Britain enabled him to perform a service of inestimable value as a clearing house for scientific information. War today is dependent on science in a degree never known before, and innumerable researches have to be carried on with expedition and without unnecessary duplication. Hence the vital importance to each country of prompt and accurate information regarding the work already completed by its allies.

On his return to New Haven a few months after the Armistice, Bumstead found the University in the midst of reorganization. His remarkable power of coördinating the divergent view-points of others and his excellent judgment made him much in demand as a member of the committees which were moulding the future Yale. He gave freely of his time and his strength, in spite of his desire for the opportunity to devote himself to a life of quiet study and research. Finally came the call to succeed Dr. Angell—Yale's president-elect—as chairman of the National Research Council. The occupant of this position is changed annually, so his acceptance would necessitate only a single year's leave of absence from Yale, and he did not feel justified in refusing the opportunity of a wider service. His executive ability and power of drawing the best out of others made his success in his new position a certainty.

He was not, however, destined to live out his term of office. The day after Christmas, 1920, he took train for Chicago to attend the annual meeting of the American Physical Society. To his many friends who talked with him there, he appeared to be at the height of mental and bodily vigor. On Wednesday evening of this week he attended a meeting of a committee of which the writer happens to be a member, and contributed his keen analysis to the discussion until almost midnight. Friday he started on the return trip to Washington. Saturday morning he was found lifeless in his berth.

Professor Bumstead's power as a teacher was even greater than his ability as a scientist. Since the death of Professor Gibbs, his courses in Electrodynamics and Electromagnetic Theory of Light have been the inspiration of the graduate work in physics at Yale. He has never been too busy or too hurried to spend an hour discussing a knotty problem with a member of his class. Not only has he given freely of his time, but on occasion he has even extended financial aid to needy graduate students. His illuminating discussions at the meetings of the Physics Club were eagerly looked forward to by both students and colleagues.

Eminent as a scientist, inspiring as a teacher, he was peerless as a man. Always cheerful and ready to lend a helping hand to others, he was loved alike by students, colleagues, and everyone who had the good fortune to come in contact with him. His high ideals, in human relationship as well as in scientific attainment, have had a profound influence in moulding the characters of the young men whom he has trained. His body may turn to dust, but his soul lives on in the hearts and minds of those who have been left behind to carry on his work.

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YALE ENGINEERING ASSOCIATION

(Continued from Page 28)

All astronomical measurements and studies are made by means of light for we have no other possible method of communication with stars and planets. To illustrate the rapidity of travel of this medium Mr. Hibben stated that if he were to speak into a microphone his voice might be heard in Australia before it would reach members of the audience in the rear of the room. The electric waves which would carry the sound by radio and wire are the same phenomena as light. They travel at a speed of 186,000 miles a second.

Among the modern uses of light is the stimulation of growth and development in vegetables and flowers. Illustrations of two Easter lilies grown from the same seeds show one plant which has been subjected to special artificial lighting to be very much larger and more fully developed after a given period of time than the other. Just why this occurs we do not know, but numerous studies have demonstrated that it is a fact. Another interesting use of light waves is to measure accurately the quality of any particular color which it is desired to reproduce. To an artist the rose is a brilliant crimson flower. To the light physicist it typifies a surface which when exposed to sunlight reflects predominatingly light of those wave lengths which create the sensation of crimson on the human eye and brain. Accurate measurements may be made of the reflections of lights of different wave lengths by a given object and from these exact reproductions of the shades in the original may be assured.

Most electric lamps produce only radiant light. The largest incandescent lamp now obtainable commercially has a rating of 10,000 watts. One of these was demonstrated while the audience shaded their eyes. But there are many kinds of light, not in the visible range, which may be generated by special means. One of these of which much is heard, is the ultra-violet or sunlamp which gives the short waves of therapeutic value. In addition to its medicinal uses, it may be employed to detect the presence of metals in specimens of ores or for special lighting effects. From many viewpoints, scientific, architectural or decorative, there is no end to the possible uses for this wonderful product, artificial light. As we learn more of it and of its possibilities we realize that we are dealing with a strange and wonderful medium.

Among the exhibits which were open for inspection after the lecture there were innumerable items of interest. A photoelectric cell device, excited by light from the automobile lamps, actuates relays and causes a motor to open the garage door as the car approaches; another similar robot turns on the lights in a factory or schoolroom when the sun approaches the horizon; an automobile demonstrates the correct focus and design of automobile headlights; a complete miniature airport lights up at the approach of an airplane; railway signalling, lighting and control is demonstrated; a miniature replica of Times Square flashes its numberless electric signs.

SUGGESTIONS TO THE EDITOR.

ONE of the distinguished members of the Engineering Association has properly expressed the opinion that the Association's Department in the Yale Scientific Magazine should contain more news about the members. He has even gone so far as to suggest that poetry be included. While we are printing a sample of poetry submitted by him, we hasten to express the opinion that the literary abilities of our members should be concentrated elsewhere. We do wish however, that members of the Association would realize that their fellow members are interested in their activities and whereabouts and hope that all items will be forwarded to the editor in care of the Yale Club, New York City.

The afore mentioned poem:

The Rhyme of the Cruel Editor.

Eight little pages pure and white as heaven.
One had a blot on it. Then there were seven!
Seven little pages felt the Editor's rough kicks.
One died of terror. Then there were six!
Six little pages still partially alive.
One more murdered cruelly. Then there were five!
Five little pages. "Copy" was so poor.
Still another missing. Then there were four!
Four little pages. Not a thing to see.
Yank out another one. Then there were three!
Three little pages. Not a word that's new.
Cut off another head. Then there were two!
Two little pages. Not a — thing done.
Even two's too many. Then there was one!
One little page.—'Twas more trouble than fun.
Into the waste basket! Then there was none!
L'envoi
Eight, seven, six.—Five, four, three.—Two and one.
K. O. for the Editor.—Didn't he have fun!

Mr. Francis C. Pratt, '88S., a former president of the Association and one of Yale's most distinguished graduates, died on January 26th, 1930.

The following is Mr. Pratt's biography as it appeared in the Forty-Year Book, Class of '88S.:

"Francis Cole Pratt, born at Hartford. Conn., January 19, 1867. Married October 2, 1901, at Hartford, Bertha, daughter of John Evert DeWitt, president of the Union Mutual Life Insurance Company of Portland, Maine, and Naomi Newell Hawley DeWitt. Children: (1) Francis DeWitt (Yale '25), born May 4, 1903; in the publicity department of the General Electric Company, Schenectady (2) Ruth DeWitt (Miss Porter's School and Paris), born April 3, 1906.

"Pratt was vice-president of the General Electric Company, in charge of engineering, for several years and later vice-president in charge of engineering and manufacturing and chairman of the manufacturing committee and a member of the advisory committee. He resigned in 1927 after twenty-one years with the company. He is a director of the Schenectady Trust Company and of the Morris Plan Company.

"During the war Pratt was a member of the Munitions Standard Board of the Council of National Defense and participated actively in local undertakings in connection with the war. Mrs. Pratt was active in Red Cross work.

"Pratt is a member of the Board of Trustees of the Sheffield Scientific School and of the executive committee of the Yale Alumni Advisory Board, and he is an ex-officio member of the executive committee of the Yale Engineering Association and a former president of that organization. He believes that every Sheff graduate, whether in the engineering courses or not, should give the association the moral support of membership.

"Yale conferred the degree of M.A. upon Pratt in 1925, and he was made a Chevalier of the Legion of Honor in 1901.

"He is a former president and present member of the board of managers of the Ellis Hospital in Schenectady, a member of the American Society of Mechanical Engineers, and an associate member of the American Institute of Electrical Engineers.

"His clubs include the Mohawk Club, the Mohawk Golf Club, the Edison Club, and the Schenectady Country Club of Schenectady, the University and Yale clubs of New York, the Yeaman's Hall and Yeaman's Hall Hunting clubs of Charleston, S. C., the North Woods Club of Minerva, N. Y., and the Tourilli Fish and Game Club of Quebec.

"He has delivered occasional lectures on industry and engineering education and extention for the industries.

"Since his retirement from business Pratt has maintained a residence at Schenectady, but spends his summers in New Hampshire. He rides horseback and lives out-of-doors much. Incidentally, he sees as many of his classmates as possible as frequently as possible."

MISCELLANEOUS NOTES.

Mr. Oliver S. Lyford, '90S., was recently appointed principal receiver for the American Piano Company and is now located at the Company's office, 584 Fifth Avenue, New York City.

* * *

Mr. Oliver S. Lyford, '90S., has been appointed as a representative of the Yale Engineering Association on the Alumni Advisory Board to succeed Mr. Francis C. Pratt, '88S., deceased.

MECHANICAL ENGINEERING

(Continued from Page 32)

home comfortably and it is hoped that before long he may be able to resume his customary activities. His work, for the second term is being carried by Professor Keator, Mr. Best, Mr. Anthony and Mr. Mason Smith.

MEDICINE

(Continued from Page 30)

Dr. W. Spielmeyer, the head of the Psychiatric Research Institute in Munich, is the guest of the Yale University School of Medicine. Here he will deliver a series of three lectures, and will assist in organizing the division of neuropathology.

Through a gift of $500,000 from the Rockefeller Foundation, Yale University has been able to acquire 200 acres of land near Orange Park, Florida, on which it will establish a laboratory station for the breeding and scientific study of the anthropoid apes. The station will be under the general supervision of Professor Robert M. Yerkes, who began the work in comparative psychobiology at Yale. Studies of the anthropoids, such as will be made by the division of comparative psychobiology, will be incorporated in the program of the newly organized Institute of Human Relations.

Among those doing research in the biological and medical sciences on Sterling Research Fellowships are two students from Germany working in the Osborn Zoological Laboratory with Professor Ross G. Harrison. Hans Bytinski-Salz, Ph.D. University of Berlin 1928, and Ernst Scharrer, Ph.D. University of Munich 1927, are working in the field of embryology. In the department of Internal Medicine, David Mitchell Kydd, M.D. Harvard University 1928, is working with Professor J. P. Peters on the chemical problems of metabolism with special reference to the acid-base equilibrium. Douglas Hamilton Sprunt, M.D. Yale 1927, M.S. 1929, is studying some of the physiological changes which occur in the blood of mammals after exposure to the Roentgen ray.

Karl George Walter Hellmich, Ph.D. University of Munich 1929, is an honorary Research Fellow in zoology. He is working with Professor Harrison on the regeneration, transplantation, and culture of the tissues of amphibians. Alice Gertrude Renfrew, Ph.D. Yale 1927, and Elizabeth Gilman Roberts, Ph.D. Yale 1927, are continuing their investigations upon the tubercle bacillus at the Sterling Chemistry Laboratory. In Physiological Chemistry, Richard Willet Jackson, Ph.D. University of Illinois 1925, is continuing his research upon mineral oil with special reference to vitamin economy in nutrition.

As Alexander Brown Coxe Fellow, Sophie Bledsoe deAberle, Ph.D. University of California 1927, working in the Department of Clinical Medicine, is making a study of the structure and activity of mammary glands. On the Seessel Fellowships, Basile Joseph Lyet, D.Sc. University of Geneva 1925, is studying the application of the laws of modern physics to the laws of growth, and Robert Hugh Wilson, Ph.D. University of Michigan 1929, is working on the intermediary metabolism of amino acids. Ava Josephine McAmis, Ph.D. Yale University 1929, is investigating the applications of physiological chemistry to medicine, particularly to fat metabolism. The Rockefeller Foundation has granted a fellowship to William Mathias Shanklin, Ph.D. Yale University 1929, to carry on research in anatomy.

CIVIL ENGINEERING

(Continued from Page 31)

25 on "The Work of the Port Authority in the Field of Port Development." Doctor David B. Steinman, Consulting Engineer of New York, addressed the Chapter, January 30, on "Fifty Years of Bridge Building."

Plans for the three-weeks summer school for civil engineering teachers to be held at Yale during the first three weeks' of July are maturing rapidly. The school will be one of a series that have been held under the general direction of the Society for the Promotion of Engineering Education during the past three years. In the summer of 1927 two schools for teachers of Engineering Mechanics were held, one at Cornell University, and one at the University of Wisconsin. In the summer of 1928, a school for teachers of Electrical Engineering was held at the University of Pittsburgh and a school for the teachers of Physics at the Massachusetts Institute of Technology. In the summer of 1929 a school for teachers of Mechanical Engineering was held at Purdue University. The school at Yale is the first to be held for teachers of Civil Engineering.

Professor Tracy will serve as Local Director of the school and Professor Suttie as Secretary. Professor Harry P. Hammond of Brooklyn is the Director representing the Society for the Promotion of Engineering Education. This society, the A. S. C. E. and the University are joint sponsors for the school.

About one hundred teachers of all ages from various colleges throughout the country are expected to enroll as students. The faculty will consist of approximately fifty lecturers, all of them either leading civil engineering professors or well known practicing engineers. The curriculum is divided into two parts. Under general subjects will be included topics relating to educational principles and practices, the aims and purposes of civil engineering education and of its principal divisions, the civil engineering curriculum, the teaching of values and costs, the teaching of engineering materials, the history of civil engineering, and the ethics and ideals of the engineering profession will be discussed by members of the staff and by members of the summer school group. A portion of the program will be arranged in three divisions, one for teachers of structural engineering, one for teachers of hydraulic and sanitary engineering, and one for teachers of highway and railway engineering.

A feature of the session will be a three days' visit to the Yale Engineering Camp.

Professor Dimitri Pavlovitch Krynine has been appointed Research Associate in Transportation in this Department. He has been professor of engineering at Moscow Superior Technical School and Moscow Institute of Transportation Engineering, Moscow, Russia. His works in Highway Engineering are well known; a text book (in Russian) is now in its third edition. His publications in English have appeared in the Transactions of the American Society of Civil Engineers and "Public Roads" the official journal of the United States Bureau of Public Roads.

It is expected that Professor Krynine will conduct research in soil mechanics and a seminar for instructors and the more advanced students. His work began early in February.

A SHEFF MAN PRESENTS HIS VIEWPOINT

(Continued from Page 6)

Because of our Fraternity System and our size Sheff offers an opportunity for fuller individual development and expression. The best in each of us is encouraged, and paths of progress are open to us by the interest and support of the fraternity. Unless he has exceptional ability or strong connections, a man may be completely submerged in as large a group as that in the College. Here in Sheff, growing and over-population neither exclude good men from fraternities nor deprives them of that portion of social life which is rightfully theirs.

This is he information upon which the members of the Class of 1933 should make their decisions. Sheff offers the more modern and valuable education coupled with a superior fraternity system, an equal opportunity for distinction and a superior social life. If you desire to become a classical teacher or if you wish to work after graduation under the

(Continued on Page 37)

AMMONIA COMPRESSOR LUBRICATION TESTS

(Continued from Page 17)

of the ammonia at these temperatures is driven off from the oil by the heat.

Ammonia lowered the pour and cold points of the oils. This effect follows the well-known generalization in chemistry that the freezing points of solutions are lower than that of the pure solvent, the extent of lowering depending on the molecular concentration of the solution. In the case at hand the lubricants at ordinary temperatures were essentially solutions.

The flash and fire points were substantially unaffected because at these temperatures the ammonia was practically driven off from the oil restoring it to its original state more or less.

In selecting a lubricant for the unit with which this experiment was carried, consideration should be given to the amount of oil that leaves the compressor because a certain level of oil in the compressor has to be maintained in order to prevent undue heating of the rotating elements. This point is of minor importance if an oil trap on the discharge line is so designed as to cause the oil that leaves the compressor to flow back into the compressor casing.

Conclusions.

1. On the basis of the overall efficiency of the compressor-motor unit and of the actual coefficient of performance, the refrigeration unit operated best with Oil III as the lubricant.
2. The specific gravity, pour and cold points of the lubricants were lower after the tests than before.
3. The flash and fire points and the viscosities at 130°F, 140°F and 210°F are practically the same before and after the experiment.
4. The viscosities at 100°F and 104°F were higher after the tests than before.

Acknowledgement.

The author wishes to acknowledge his indebtedness to Assistant Professor Lauren E. Seeley, of the Department of Mechanical Engineering Sheffield Scientific School, Yale University, whose suggestions and encouragement have been instrumental in carrying out this work, to Assistant Professor L. C. Lichty, of the same Department, for his helpful suggestions and to Mr. John D. Marsh, Laboratory Engineer of the Department, for his help and good advice during the design and construction of the condenser.

COORDINATED EFFORT OF PUBLIC UTILITIES

(Continued from Page 19)

The above cases are examples where coordinated effort is required to minimize the effects of the voltages and currents that one utility might have on others, and are typical of many such problems that are being presented to the engineers as the various systems grow and develop.

There are also other problems of a more physical nature that require very close cooperation, especially on the part of the wire using utilities, to overcome. The results of these efforts are more in evidence to the public and a concrete example may be seen along many of our highways in the form of pole lines used jointly by Electric Light and Telephone Companies.

In considering the joint use of poles, the wire using utilities recognize their responsibility to serve their customers safely, adequately and economically. Many items, therefore, have to be given very thorough consideration on the part of each utility to properly live up to this responsibility. Some of the more important items considered are:

(1) What types of electric light circuits and telephone circuits are suitable for joint use.
(2) What strength and type of construction should be used.
(3) What should be the relative position of the different classes of circuits on the pole.
(4) What would be the proper separation of the various classes of circuits to allow employees of the various utilities to work on these poles safely.
(5) What would be the allocation of costs between the various utilities involved.

The success of the coordinated efforts in agreeing to specifications for the joint use of wood poles is shown in Figure 1. This figure shows the relative positions of the different classes of circuits on the pole, the minimum vertical separation between them, and the minimum horizontal separation required for climbing space. Fig. 2 is a photograph of a joint use pole line in accordance with these specifications.

To assist the numerous wire using companies in overcoming their mutual problems, various committees, national in scope, have been formed to study, coordinate, and recommend the best practices to follow for rendering dependable service. One such committee is the Joint General Committee of the National Electric Light Association and the Bell Telephone System on the

physical relations between electrical supply and communication systems. The chairman of this committee is Mr. Owen D. Young of the General Electric Company. A few of the recommendations already made by this committee include subjects such as Principles and Practices for the joint use of wood poles by supply and communication companies, and cover the general engineering and operating features which are met with in the field. Another important recommendation is in regard to the Principles and Practices for inductive coordination problems from a physical standpoint.

There is also a Joint General Committee to handle similar problems that may arise involving the relations between electric light and power circuits of the member companies of the National Electric Light Association and the circuits of the Western Union Telegraph Co. Mr. Owen D. Young is also chairman of this committee.

The above are only a few of the problems and the coordinative methods employed by the various utilities in their endeavors to fulfill their responsibilities to render dependable service to their customers. As the various systems expand, as new developments are made available in apparatus and methods of operation, and as greater requirements for dependable service are demanded by the public, the necessity for the proper coordination of effort by the public utilities is becoming increasingly important.

A SHEFF MAN PRESENTS HIS VIEWPOINT

(Continued from Page 35)

handicap of inadequate training, the College is the proper school. If you have ambitions to fill an important position in our modern world, Sheff gives the more adequate preparation.

A CHALLENGE TO THE IMAGINATION

LEE DE FOREST, INVENTOR OF THE AUDION

(Continued from Page 5)

phone Company, which one year later purchased the exclusive wire telephone rights under twelve Audion patents. As a result of this that company was enabled, early in 1915, to open up the trans-continental telephone service, New York City to San Francisco. In 1913 Dr. deForest returned to New York, and established the deForest Radio Telephone and Telegraph Company. The Audion amplifier, the Ultraudion detector, the Oscillion, or oscillating Audion as generator of alternating currents of any frequency, were rapidly perfected and marketed. It is impossible to overestimate the importance of this invention in the world today. (It has probably done more to stimulate interest in science and scientific thinking than any other discovery). The introduction of the grid electrode made possible telephone and radio communication as we know it as well as an impressive and ever-increasing list of industrial applications.

He has been the recipient of many honors, among them the Gold Medal of the St. Louis Exposition in 1904 for work in wireless telegraphy; the Gold Medal of the San Francisco Exposition in 1915 for his work in radio telegraphy; the Cross of the Legion of Honor from France; the Elliot Cresson Medal from the Franklin Institute; the Medal of Honor from the Institute of Radio Engineers; and the John Scott Medal from the City of Philadelphia for his development of the audion. He received an honorary degree from Yale in 1926, and last year he was made an Alumni Member of the Yale Chapter of Sigma Xi. It is but just to say that Dr. deForest, by his invention and development of the audion, has changed the course of everyday life in all its phases.

AVIATION'S TREND TOWARD INVERTED ENGINES

(Continued from Page 10)

but it is sufficient for the purpose of this article to indicate that such a trend does exist and will bear watching by those interested. Each new Air Show finds a new motor company exhibiting an inverted motor of the type we have been discussing. At present over six companies are working on models which will find extended applications in 1930. Competition in the low powered class will be rife as these new motors tend to displace the very popular radial and upright in-line motors. It is probable that future developments of inverted types will lead to high speed supercharged and geared engines which will represent a decided power increase for unit engine displacement. Already such engines in higher powers of the Vee type have been developed experimentally for military use and are undergoing tests at the present time. As the demand for increased power grows the in-line inverted engine will find natural development into Vees and X type motors where it will be more able to compete with the radial in weight per horsepower.

MENTAL DISORDERS TREATED BY PSYCHIATRY

(Continued from Page 13)

ness. It keeps alive our primitive and medieval ideas. Mental disorder should hold no more horror than any of the physical diseases. It is an illness which responds to the proper treatment.

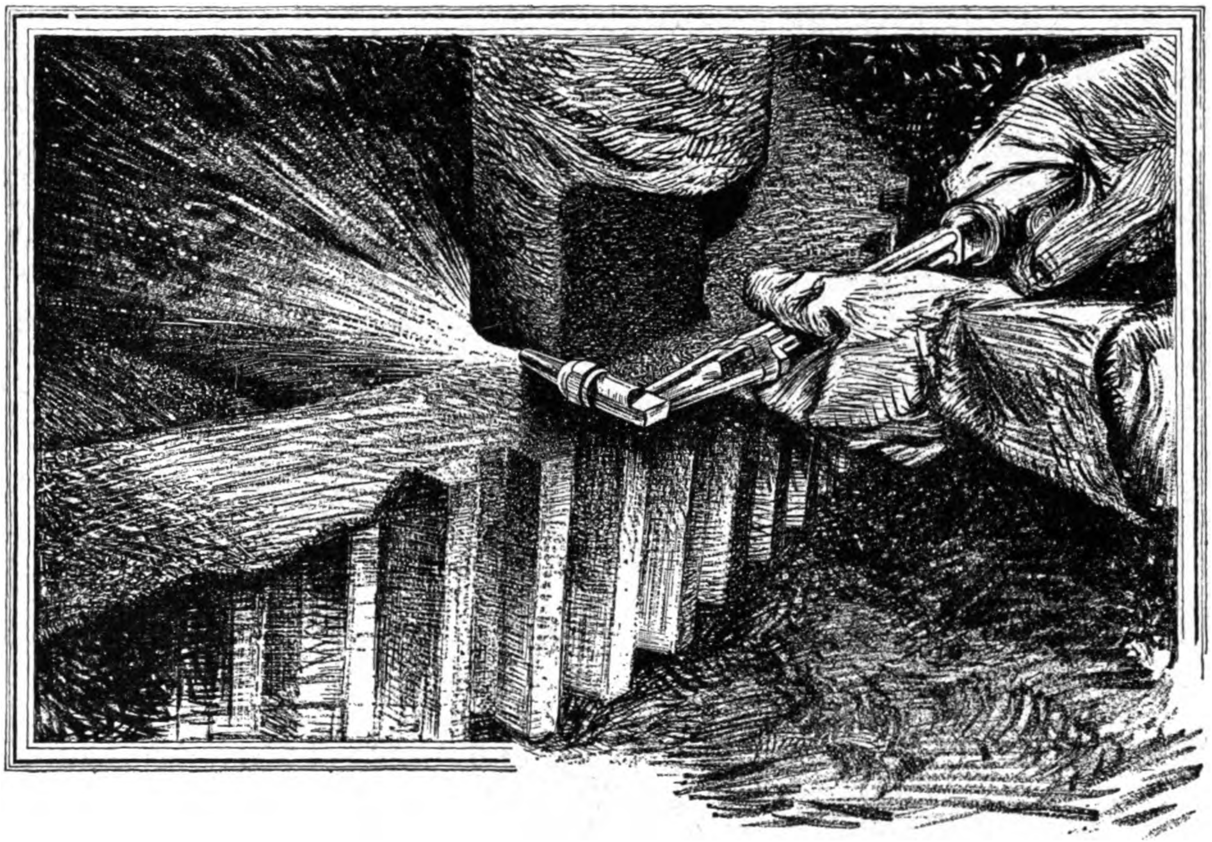
PERSONALITIES

(Continued from Page 29)

to be a rather mild form of diversion but it is, in fact, quite a strenuous one. To begin with each of his sons has shown indications of having well above the average ability in athletics, and naturally Professor Miles finds it a pleasant duty to be a faithful spectator at their games. This duty takes him from time to time to Hartford for a state tennis tournament, to Culver for a national tournament or to Lawrenceville for a football game. Egbert, the oldest, has to his credit three state championships in boys tennis and one in the junior division. Richard Curtis acquired the boys title as soon as Egbert reached the age limit.

Traditionally mathematics is an exacting and tedious science and it is feared that mathematicians themselves share to some extent the opprobrium which their subject suffers. The frequent association of the adjectives "cold" and "calculating" is eloquent evidence of their general disrepute. It is hoped that by citing Professor Miles there may be still "another ancient prejudice removed". After his success in the classroom there is his success in his office, for to many he is friend and counselor as well as teacher. His office hours, though liberal, often must be extended to accommodate his callers who range from the novice struggling with the "four-step rule" to the graduate student in engineering who has turned up a differential equation of forbidding aspect. Nor is the talk confined to mathematics. More per-

(Continued on Page 46)



TIME—THAT TOUGH OLD TESTER . . . .

Meet Time, that tough old tester of everything in this world. To his aid, Time calls all the destructive forces of the universe. Years come and go, storms and sunshine, heat and cold make their accustomed rounds, while Time, the tough old tester, broods over the world, trying, testing, destroying.

Yet Time, the tough old tester, does have his troubles. Against one material devised by man, Time and his serving-men falter. That material is genuine Puddled Wrought Iron—the metal of which Reading 5-Point Pipe is made. Watch for the next coming of Time, the tough old tester—you can learn about pipe from him.

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READING PIPE
DIAMETERS RANGING FROM 1/8 TO 20 INCHES

Science and Invention Have Never Found a Satisfactory Substitute for Genuine Puddled Wrought Iron

PERSONALITIES

(Continued from Page 42)

sonal problems are submitted to him and many a man has gone out of his office stimulated by a little vigorous conversation.

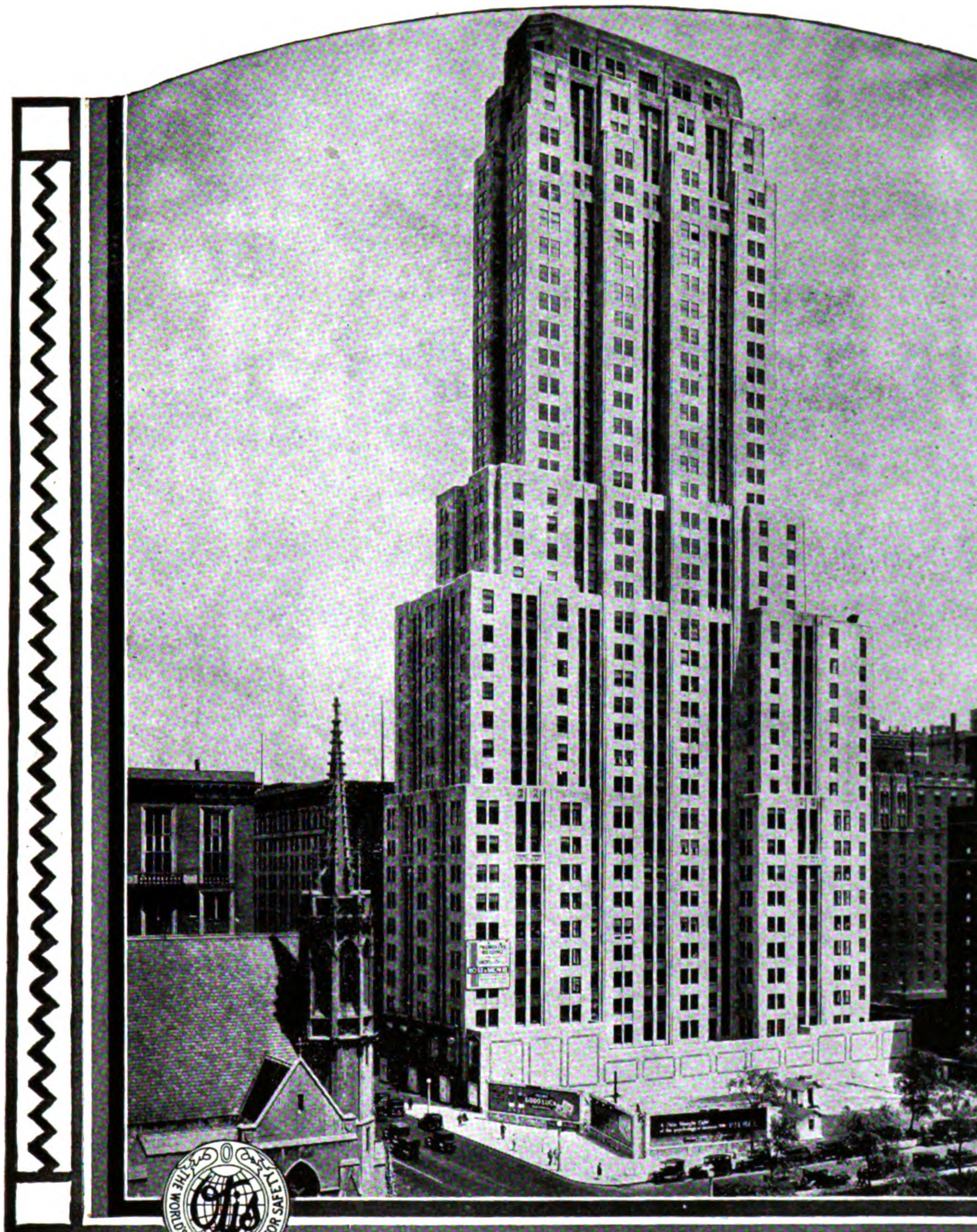
Allusion has already been made to the effectiveness with which Professor Miles can emphasize a point by employing a little physical force. For those who have been in his classes there is no need to go into any details as to what is meant. To make it clear to the others we shall admit them for a moment to his classroom in Thirty-Eight, North Sheffield Hall. It is an eight-twenty, toward the beginning of the year, and the class is at the board. Professor Miles moves restlessly around the room checking results and correcting mistakes. By the window there is one who shows considerable indifference to his task and is on the point of letting his thoughts drift off with the smoke pouring out of Winchester's turret. A hearty blow between the shoulders hurries him back to the world of reality and a wave of incipient anger quickens his pulse. Professor Miles is quick to take advantage of this sudden increase in available energy and with a few well chosen words directs it into useful channels.

Ordinarily one incident of this kind is sufficient to keep the attention of even an eight-twenty at the proper pitch. Of course if more applications are necessary they are forthcoming and a certain number are administered impartially, and probably subconsciously, on the class as a whole. It is very effective but Professor Miles confesses that he dreads to think what may happen some day to a girl student in one of his graduate classes.

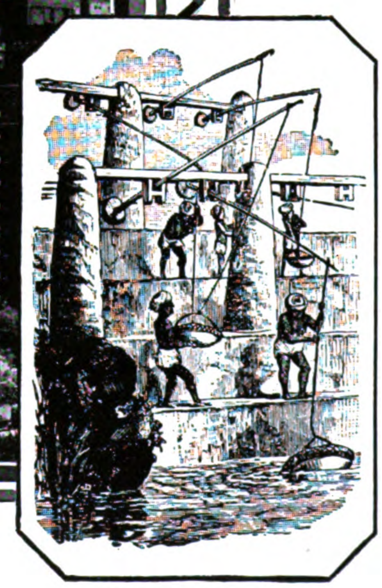
MINING AND METALLURGY

(Continued from Page 30)

will be presented at the Hammond Laboratory on various dates during March and April.



PALMOLIVE BUILDING, CHICAGO, ILL.
Holabird & Root, Architects



One of the early phases of Vertical Transportation

A New Chicago Skyscraper

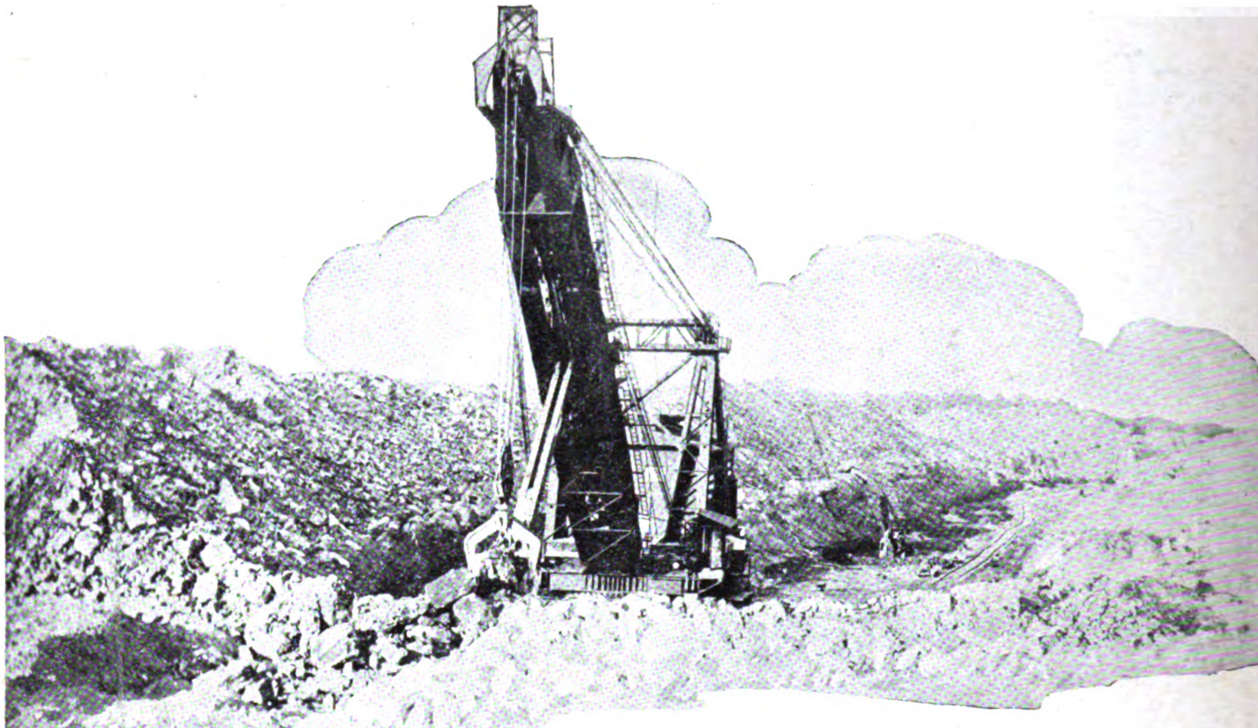
THE Palmolive Building, Chicago, although completed only a short time, is already a famous office building. It is served by 12 Otis Signal Control Elevators for passenger service.

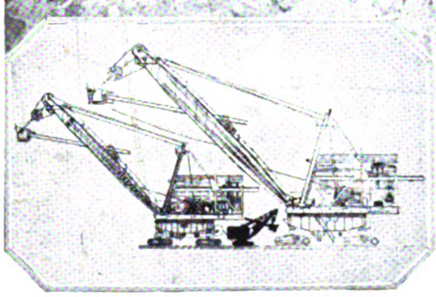
In such an outstanding structure as this it is imperative that nothing but the finest equipment be used and Otis Elevators, with their world-wide reputation for safety and reliability, were the natural choice.

Over 75 years research and manufacturing experience are behind Otis Elevators, which are made by the same organization that has pioneered the way with every important development and major improvement in the entire field of Vertical Transportation.

OTIS ELEVATOR COMPANY

OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD





A comparison: the big shovel; the previous record size; and, in solid black, the standard-size excavating shovel

A One-man shovel 9 Stories High

ONE man easily controls the excavating operations of the world's largest shovel, now stripping coal at Duquoin, Illinois. Yet this shovel weighs as much as 20,000 men.

Its 15-cubic-yard dipper can pick up, at one bite, enough coal to heat a good-sized dwelling for a year (about 16 tons). The highest point on the shovel equals the height of a nine-story building.

General Electric, a leader in the application of electric power to industry, installed the electric equipment, aggregating 5500 horsepower.

The planning, testing, and distribution of electric equipment are largely the work of college men who are members of the General Electric organization.

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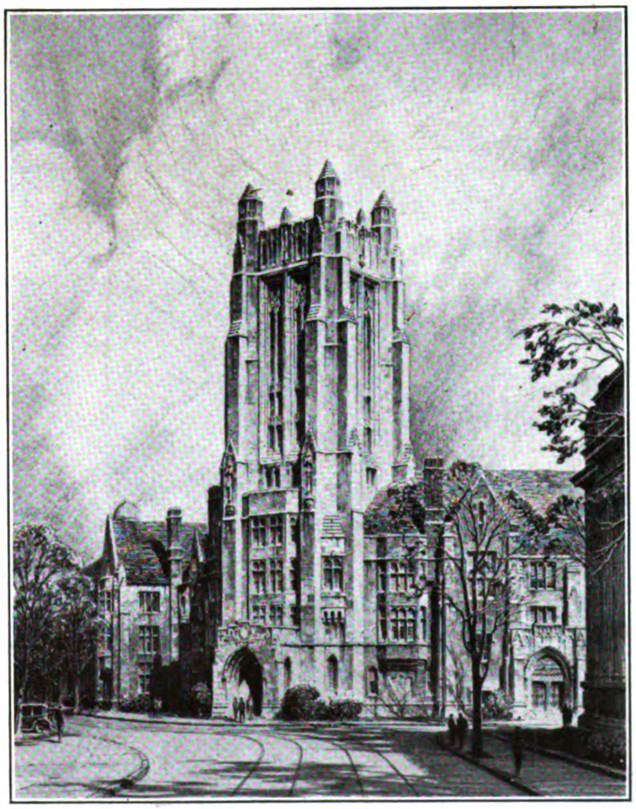
THE YALE SCIENTIFIC MAGAZINE

VOL IV MAY, 1930 No. 4



The Proposed New South Sheff ***Administration Building.***

PUBLISHED QUARTERLY IN THE INTERESTS OF
SCIENCE AND ENGINEERING
IN THE SHEFFIELD SCIENTIFIC SCHOOL

WHAT YOUNGER COLLEGE MEN ARE DOING WITH WESTINGHOUSE

Equipping A Cathedral of Learning for the University of Pittsburgh

Nine years ago the University of Pittsburgh, then a hundred and thirty-six years old, faced an urgent need for larger quarters. To extend its restricted campus was almost out of the question, for a city had built up around it. The logical direction for expansion was into the air.

American business had long before faced the same situation, and met it with the skyscraper. But no conventional business building would satisfy here. Chancellor John Gabbert Bowman envisioned a Cathedral of Learning, an edifice that would express the essential self of the steel center of the world, a structure with more power, more spirit of achievement and reverence in it than had ever before been attempted. A great architect put his soul into the making of the plans. Leading suppliers were called on for the materials for the realization of Chancellor Bowman's dream.

To Westinghouse engineers came the assignment of providing the electrical and elevator equipment for this great structure. Recognized as a great clearing house for electrical development, the Westinghouse organization draws interesting assignments in every field of human activity.

H. O. KOEHLER
University of Illinois, '22
Application Engineer

H. J. PETERSON
University of Washington, '26
Control Engineer

E. N. BALDWIN
Purdue University, '22
Engineer of Mechanical Design

R. A. GAUT
Pennsylvania State College, '25
Field Engineer

C. F. CARNEY
University of California, '26
Control Engineer

Westinghouse

THE YALE SCIENTIFIC MAGAZINE

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THERE will undoubtedly be those who will demur to the replacement of the present Sheffield Hall at the head of College Street on Grove by a new building, no matter how beautiful—and all who have seen the sketches prepared by Mr. Clarence C. Zantzinger, of the Class of 1892 S., must concede their great dignity and charm. I confess that I share somewhat this feeling of regret that an old and faithful servant should be dismissed, no matter how ill favored his features. It is the inability of the old servitor longer to render the needed service which constitutes the compelling reason for the proposed change.

The necessity for more adequate accommodation for the work of the Scientific School is easily demonstrable. The work in transportation has never had a local habitat of its own and much needs it. Indeed, it may be doubted whether it can ever function very effectively until it does have appropriate quarters which belong to it. Fortunately the great foundation established by Lord Strathcona in 1914 will meet the cost of the portion of the building devoted to this transportation work.

The site is probably the most commanding in the University's present holdings, and a building at this point, such as the architect has designed, will add greatly to the impressiveness of the University group at that important corner, and will bring the Scientific School back into the architectural picture of the new Yale. It remains only to find the resources to erect the tower and the main portion of the structure.

James R. Angell.

History of the Birthplace of Sheff.

News of Planned Replacement of Old South Sheff Hall Brings to Prominence Its Varied History.

By Dean Charles H. Warren.

The Early Home of Scientific Work at Yale

THE publication in the *Yale Alumni Weekly* of March 28 of plans for a proposed new building to replace Sheffield Hall, or "Old Sheff" as it is often called, has naturally revived not a little interest in this old landmark of the Sheffield Scientific School and indeed one of the landmarks in American science. It may therefore be not inappropriate to devote a little space to recalling to mind the part which this building has played in the history of science at Yale and in the country.

As is well known, Sheffield Hall was not the building in which scientific work and instruction in science was started at Yale. The old "President's House" claims this distinction, for it was the latter, an old frame building, built in 1799, and occupied by President Day and the first President Dwight, that was rented by Professors Benjamin Silliman and John Pitkin Norton for the sum of $150 per annum from the Corporation of Yale College in 1847 for use as a chemical laboratory. By the end of the next decade the work in the "school of chemistry" had grown surprisingly, a "school of engineering" had been added, and the two had been combined into what was known as the "Yale Scientific School." It had outgrown its first home.

Mr. Joseph Earl Sheffield of New Haven had, in common with several other progressive citizens of the city, taken a keen interest in this new educational movement, and fully recognizing the needs of the school for more adequate quarters, he purchased in 1858 the building on the corner of Grove and Prospect Streets which was then being used for medical instruction by the Yale Medical Institute, and gave it to the Yale Corporation to be used for the purpose of the scientific school. The original building was a plain, rectangular, three-story affair. Mr. Sheffield added to it two wings, extending to the east and west, altered and refitted the interior to better adapt it to the purposes of the school, and provided what was in those days a very substantial endowment.

It is worth while pausing here for a moment to comment on Mr. Sheffield's gifts. This particular donation as well as later gifts and bequests made by him to the School, which most fittingly bears his name, were in the aggregate substantial even as measured by modern standards, and compared with gifts to educational work during the latter half of the nineteenth century, they were truly munificent. Few men of his generation were possessed of sufficiently large fortunes to make such gifts and still fewer were possessed of so true a vision as to the part which science was shortly to play in human affairs. Certainly no such vision was granted to those in charge of the Yale College of that day. The only part they played in aiding science was to accept such gifts evidently with a good many misgivings and with regret that the funds were not to be devoted to what seemed to them to be a better cause. Mr. Sheffield's gifts must be regarded as among the really outstanding contributions to the cause of progressive education in America.

The school moved into its new home in 1860. In 1865 the north wing was added by Mr. Sheffield connecting the older wings at the rear. At the same time the square towers, one in front and the other on the west side, were erected. The front tower with its clock and the well remembered "tank", a cylindrical wooden structure with a circular track and machinery for rotating it, was specially designed to accommodate the fine ten-foot equatorial telescope built by the firm of Alvan Clark and Son, of Cambridgeport, Massachusetts, for the use of Professor Theodore Lyman. The other tower housed a very fine meridian circle. Standard time was determined there for many years.

There was at this date nowhere in the country any building so commodious or so well equipped for scientific work. That the early faculty of the school regarded it with the greatest satisfaction and the public with respect is indicated by published references to it which occur in the press of that time.

Not only were the lectures, classroom and laboratory work in the natural and physical sciences, all of which quickly followed the earlier work in chemistry, conducted in the building, but the work in engineering, chiefly in civil and "dynamical" (mechanical) lines, was also carried on here. Here, too, were held regular series of lectures on scientific and technical topics open to the public and largely attended by them. This latter activity was designedly an attempt to educate the public in scientific matters, then new, and because of their very novelty and promise of direct usefulness possessed of a strong appeal to the practically minded citizens of the community. Nor was this gesture to the public unprofitable to the school itself. It undoubtedly resulted in securing support from interested and generously disposed individuals. Although the graduating classes were awarded their diplomas with the college Seniors in the Center Church on the Green, the other commencement exercises, which included the reading of theses, were held in Sheffield Hall and for many years constituted an event attracting much public interest. At this time the building was quite properly referred to as the Sheffield Scientific School for all of the activities of the School were carried on therein. As one looks about the University today and compares, or rather contrasts, this old building with the present splendid laboratories devoted to the sciences and engineering, it is perhaps difficult to realize that so much important scientific work could have been carried on within its walls and that so many important enterprises were initiated there.

Let us consider for a moment some of the more important things which despite all drawbacks were accomplished in this

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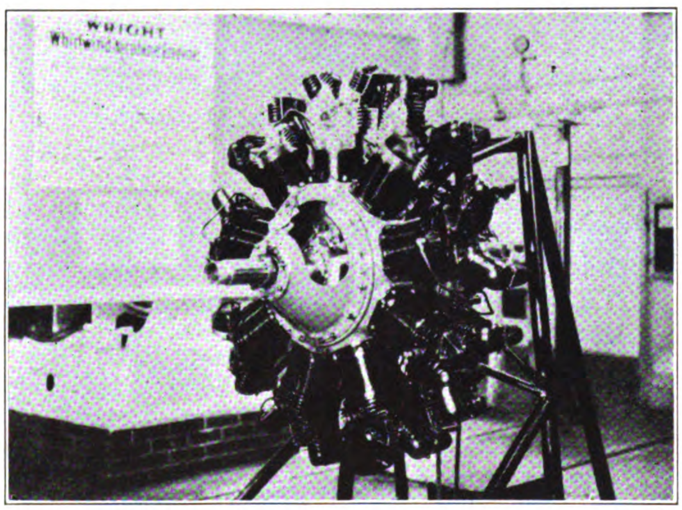
The 1930 Mechanical Engineering Exhibit

The Exhibition in the Mason Laboratory, February 21 and 22 was the first to be held in cooperation with the Electrical Engineering Department.

By Alger S. Bourn, 1930S.

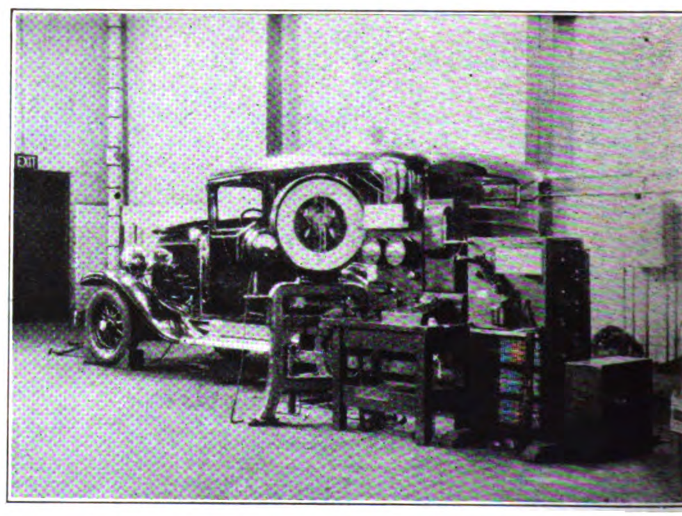
ASIDE from the fact that the exhibition of the Mason Laboratory by the students of Mechanical Engineering was held this year in conjunction with a similar exhibition by the students of Electrical Engineering, which in itself is an innovation of no mean importance, the Mechanical Engineering exhibition set several precedents which it is hoped will be carried on in the future. In the first place the very fact that the exhibition was held at all this year is something new. Formerly the exhibition had been held biennially. The second innovation was the choice of Alumni Day as one of the days for the exhibition. This choice was made so that the alumni could see just what is going on in our laboratories, and the way in which the alumni responded to our invitation was indeed gratifying. The third major innovation was the setting of the times of the exhibition as Friday evening and Saturday afternoon instead of Friday and Saturday evenings as it has been for some years past. This change was made so that those alumni who were here during the day only could see the exhibition. These changes in the order of events seemed to meet with general approval as the attendance on both Friday evening and Saturday afternoon was very large. Attendance figures can hardly be better than an approximation, but two thousand copies of the program were printed and only a few scattered copies were left when the exhibition was over.



The Wright Whirlwind engine attracted much attention.

The exhibit which was perhaps the most popular was the Wright "Whirlwind" airplane engine. The engine shown was a cut-away model of the famous J-6, nine cylinder, radial, air cooled engine, a slightly modernized edition of the one which Colonel Lindberg flew to Paris. For the purpose of exhibition the engine was mounted on a special stand. It was turned over slowly by an electric motor which was belted to its inertia starter. The job of cutting away parts of the engine was so beautifully done that all the moving parts could be easily watched as they went through their cycle of operation. Even the design of the crank shaft and connecting rods, which is so hard to comprehend unless one actually does see it, was quite obvious from this cut-away. Each one of the top three cylinders was cut away in a slightly different manner so as to show the action of the piston and the valves. There was always a crowd around the engine, and they kept Mr. Hunter busy answering their questions.

Among the other exhibits which approached the "Whirlwind" in popularity was the chassis dynamometer test of the Chrysler "77" Sedan which was very kindly loaned to us by the Biever Motor Car Company. A full performance test was run on the car during the two days of the exhibition. This included data on brake horsepower, fuel consumption, maximum grade, tire and transmission losses, and a check of the accuracy of the speedometer. This exhibition was particularly popular when Mr. Smith and his able assistants were taking the data on the high speed points. The engine would roar, the crowd would gather around, the electric tachometer would climb up to three thousand revolutions or more, Mr. Smith would blow his whistle, and readings would be taken. The throttle would then be cut, the roar would die down, and the crowd would move on to something else after learning that they had witnessed the taking of readings at seventy miles per hour.



Performance tests were run on a Chrysler "77" sedan.

Another exhibit which attracted a great deal of attention was the stroboscope. Mr. Gagnebin had quite a struggle with it to get it working; but when he finally did get it functioning properly, he had a curious crowd around him all the time while he explained how synchronized light flashes made the vibration dampener of the Chrysler "80" engine stand still.

The small 12 volt lighting set which the Malleable Iron Fittings Company very kindly loaned to us also seemed to be widely

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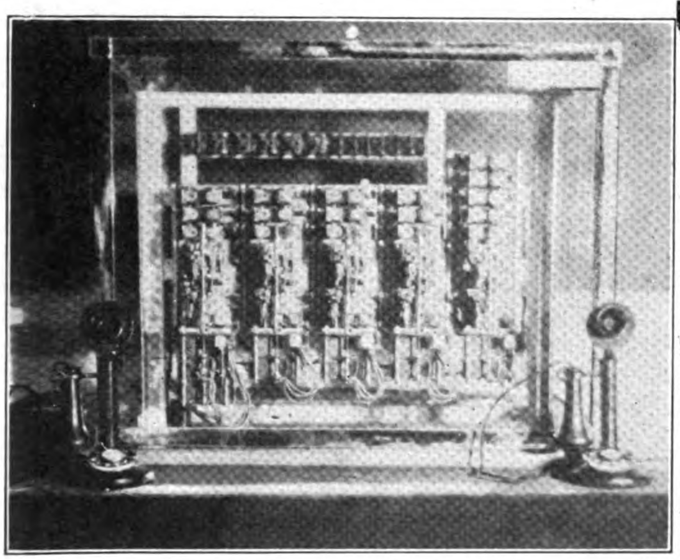
The Electrical Engineering Exhibition

A Comparison Between the Equipment of 1880 and that of the Present Day was Afforded at the Recent Student Exhibition.

By Robert B. Whittredge, 1930S.

IN the Dunham Laboratory exhibits ranged from large power machinery to delicate vacuum tubes. Most interesting was a permanent collection of historic dynamo machinery of odd shape and design, an early Edison generator of 1881 with long spindle field poles, once in service furnishing current for the university physics laboratory, a forty-five year old Brush arc lighting generator used in New Haven street lighting service from 1889 to 1912, a Siemens alternator of 1880 and other interesting machines, illustrating the groping guess-work that built electric machinery of fifty years ago and the gradual progress that brought about more efficient machines as the fundamental laws underlying electrical design came to be recognized and applied.

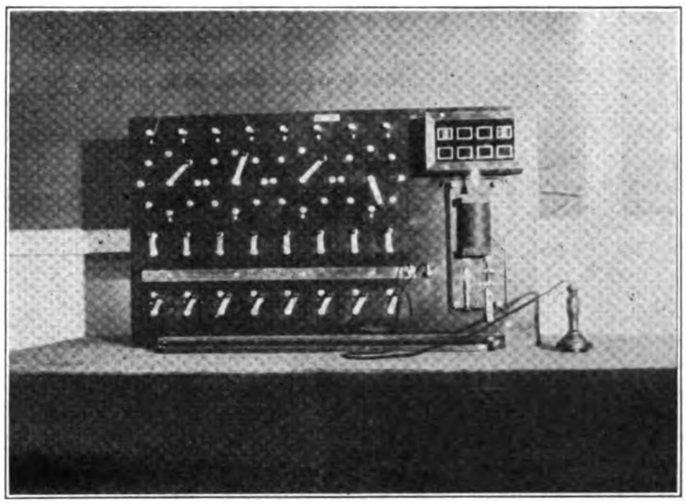
In the power laboratory one of the most interesting set-ups was a model a.c. power house consisting of remotely controlled motor driven alternators, complete switchboard and equipment for synchronizing, load shifting and control of voltage and frequency. Several pieces of machinery were under test in conducting experiments selected from those regularly carried out in the undergraduate courses of the department. A synchronous converter was in operation converting alternating to direct current, and the conversion was visually demonstrated with the aid of an oscillograph. There was also shown a generator cut-out newly developed for railway car lighting. Instead of putting the generator onto the battery charging line at a fixed generator



A modern automatic telephone switchboard at the exhibition.

voltage, as is commonly the case, this relay cuts in the generator whenever its voltage exceeds by two volts that of the battery. In this way most effective charging is obtained.

A new development in the heat treatment of high speed tool steel, the molten salt bath furnace, was exhibited, the result of the work of Professor W. B. Hall, 1916S, of the department of electrical engineering. The central part of this furnace is the heating pot, heavily lagged for the saving of heat, which contains a salt kept in molten condition by the passage of a heavy current through the resistance of the bath. Pieces to be treated are plunged into the salt bath where they are heated to the required temperature and then quenched in the usual manner. Oxidation is



In contrast to the switch mechanism at the left was this—a duplicate of the first commercial switchboard in the World.

prevented during treatment by a layer of the salt adhering to the surface of the piece; this permits complete machining to finish dimensions before treatment.

On a balcony above the main bay a new design of airway revolving beacon flashed a ten-mile beam from the windows of the laboratory, illuminating surrounding buildings with a swift splash of light. The working mechanism was enclosed under a glass dome to prevent possible failure due to severe weather conditions. Failure of the light was prevented by the use of an automatic lamp changing device which connects and brings into focus a second lamp if one burns out.

Another product of Yale research was a vehicle-controlled traffic dispatching system invented by Harry A. Haugh, Jr., 1920s. A control box receives impulses from pressure-operated pavement units registering the approach of vehicles at an intersection, classifies these and operates the dispatching light with uncanny perfection. The most complicated intersections and situations are handled by the system; even the speed of vehicles is taken account of.

Some of the methods of theatre lighting were shown in an exhibit of lighting effects. Most effective was a relief mask of a face with lights arranged about it to show the powerful effect of color and angle of lighting on appearance and expression.

Three of the many applications of electron research were exhibited in the photo-electric cell, the Knowles grid glow tube and the Thyratron. Light falling on the photo-electric cell causes a current to flow between electrodes; by varying or interrupting

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The 1930 Senior Inspection Trip

The Annual Trip of the Graduating Class in the Departments of Industrial, Mechanical and Electrical Engineering to Industrial Plants of Interest.

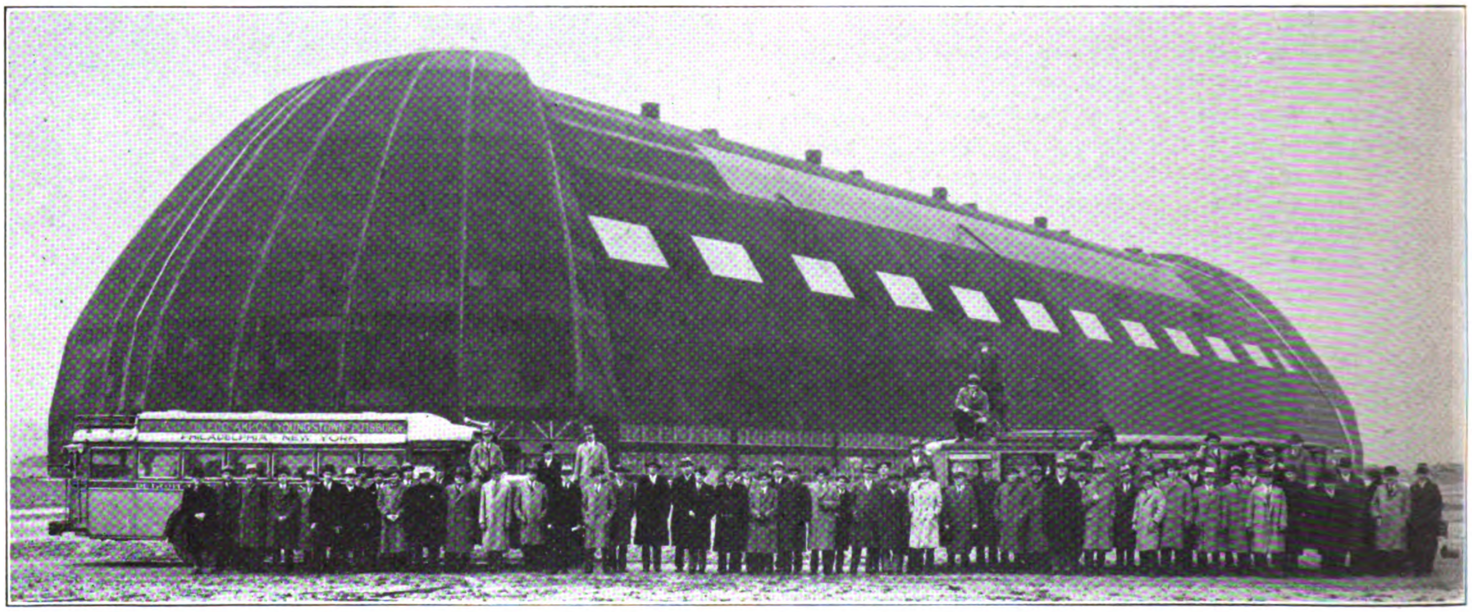
By Warren Cooke, 1930S.

NEW YORK harbor with its busy shipping; a giant open hearth furnace being tapped; fireworks attending the pouring of steel ingots; huge generators under construction; Ford cars driving off the assembly line under their own power; the ever majestic falls of Niagara—these were among the spectacular sights of the inspection trip recently completed by the Seniors in Mechanical, Electrical, and Industrial engineering. Let it not be thought, however, that the trip was a mere sightseeing tour, for it was not. It gave an opportunity for first hand study of the application of engineering, management, and economic principles taught in Sheff. Furthermore, it served as preconditioning for Seniors soon to venture into the maelstrom of industry, and taught some the line in which their interests lay.

Professor H. L. Seward, assisted by Professor L. E. Seeley and Professor P. B. Brill, ably planned and directed the industrial visits of the Mechanical and Industrial groups. The electrical engineering trip was arranged by Professor Scott, aided by Professor Hall.

For the electrical engineers the trip began the morning of Tuesday, March 25, with the inspection of the Bell Laboratories, and some of the facilities of the American Telephone and Telegraph Company in New York. At seven that evening the mechanical and industrial engineers assembled with the electrical engineers at the Yale Club, where the undergraduates were guests of the Yale Engineering Association at dinner.

Next morning all hands met at the Pennsylvania Terminal, and gondola cars were boarded which took the group through one of the four tunnels under the East River to the Sunnyside yards. After looking over the yards, the Long Island power plant was inspected, then the Yale delegation was picked up by two Pennsylvania Railroad tugs, which steamed to the Pennsylvania produce piers in the North River, where much of the perishable food supplying New York is handled. Following a short stop at the produce piers, the tugs proceeded up the river to the unfinished Hudson River Bridge. Then a course was set for the railroad's Greenville yards, in New Jersey, with a swing up the Brooklyn shore to give a view of the new liner Europa at her pier.



The Mechanical and Industrial Engineering groups in front of the Goodyear Airship factory and dock near Akron, Ohio.

When the Pennsylvania freight yards had been seen, the industrial and mechanical engineers went on to Philadelphia, but the electrical engineers returned to spend another day in New York seeing the Chrysler building, the Westinghouse Lighting Institute, and the Brooklyn Edison Company research laboratory.

In Philadelphia three different trips were arranged. The mechanical engineers visited the Westinghouse plant at South Philadelphia, the Baldwin Locomotive Company, and the General Steel Castings Company. One group of industrial engineers spent a day at the New York Shipbuilding Company and the Naval Aircraft factory. These men found the shipyard of interest because of a good layout for material handling. The other party of industrial engineers took in the Keystone Aircraft Company and Sears Roebuck and Company. The handling of mail orders proved a fine illustration of system, and the enlightened personnel policy at Sears Roebuck was a cause of favorable comment.

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Continuity and the Quantum Theory

Considerations of the Nature of Light and Its Propagation and of the Structure of Matter have Led to the Development of the Present Quantum Theory.

By Raymond J. Seeger

THE Greeks may not have been very adept at answering questions, but they certainly knew how to ask them. Take this one as an example: is space filled continuously, or not? To all practical people there are two replies. The Greeks knew both. Aristotle of Stagira said, "Yes"; Democritus of Abdera said, "No!" So the philosophers of Greece meditated, and they talked, and they wrote—meanwhile the answer remained ambiguous. A few bolder than the rest—or more bored—attacked the query from a different angle. Such a one was Zeno, who tried to analyze the nature of space and of continuity. This did not seem to alleviate the trouble.

The Renaissance revived, not only the culture of the Greeks, but also their problems. The latter were soon subjected to the experimental test required by newly born Science. What of the question of continuity? The answer was made most decidedly in the negative by John Dalton about 1808—but not before Immanuel Kant had given all his influence to the affirmative. The atomic hypothesis of Dalton maintained that matter could be considered as made up of small units, called atoms, indivisible under certain conditions. We include the last phrase because it was later found desirable to believe that these were divisible, electrically. Michael Faraday's discovery of ions—material carriers of electric charge—culminated in the determination of the electron, which is still conceived to be the smallest charge of negative electricity. To be sure, it cannot be demonstrated that the electron may not be subdivided under yet untried conditions. However, such possibilities belong to those thinkers skilled in the art of speculation, and not to scientists prejudiced against that intangible ghost called mathematical infinity. The discreteness of matter was definitely interpreted in terms of the elementary electric charge by Moseley in 1913. From measurements on the characteristic X-rays of various elements he was able to prove an inference previously drawn from Rutherfords' experiments on alpha-ray deflections by matter and from van der Broek's observations on chemical properties. His induction was as follows: the atom of each element has a nuclear charge equal to the number belonging to the position of that element in the periodic classification of Meyer and of Mendeleef. But according to Rutherford's model of the atom, there are distributed about the positive nucleus a number of neutralizing electrons, equal to the nuclear charge. Thus the indivisible unit of matter was expressed in terms of the elementary charge of electricity. Discontinuity appeared to be quite realized! But was it? For Heinrich Hertz had shown that each charge of electricity was to be identified with the continuous Faraday-field formulated by Clerk Maxwell. Thus the electronic particles might be viewed as embedded in an infinite medium—discontinuity in continuity. It is to be noted, however, that the properties assigned to this continuum, the "ether," had undergone radical changes. They had evolved from those belonging to an elastic solid, to others pertaining to a vortex—sponge. Then H. A. Lorentz deprived the medium of all its mechanical nature, save motion alone. And Einstein eliminated that! But even now on the theory of relativity, the ether remains—necessary and continuous. So strong was the case that Oliver Lodge, in 1913, expressed "a belief in ultimate continuity as essential to science". It was ironical that two months prior to this, Niels Bohr proposed a successful model of the atom based upon essential discontinuity. But this is another story.

The Propagation of Light.

The nature of light, as well as the mode and mechanism of its propagation, has aroused man's curiosity from earliest times. It was from India that Pythagoras received the idea that objects emit rays of light. There, too, the contrary notion was argued by Gautama, the reputed author of the "Nyaya Sutra". He postulated "eye-rays" which went out from the eye. Contemporary with these views was a systematic treatise written by Empedocles. In this essay was advocated a combination of the two preceding hypotheses, i.e., effluences from the eye and eye-rays from the object meeting to produce, somehow, the sensation we call light. The remarkable fact about these diverse views is that each is concerned with the same conception of the propagation of light by particles. Except for various scholastic annotations during the Middle Ages, this concept remained unchanged until the time of Descartes. The latter introduced the idea of a medium permeating space (the ether of Huyghens). Light consisted in pressure transmitted instantaneously, and thus became a continuous phenomenon, rather than a discontinuous one. His adoption of different frequencies of rotation of the particles in the medium to account for color was, perhaps, the basis for the idea of a vibratory motion suggested later by Robert Hooke. This theory was enunciated more clearly by Huyghens. He conceived light to be a quick vibratory motion, transmitted through the ether in the form of a wave. (The finite velocity of light had just been propounded by Römer to explain discrepancies encountered in observations upon the eclipses of the satellites of Jupiter). Newton objected! And his authority kept the corpuscular theory of light in the foreground for another century. Yet not without good reason: for the fact that light travelled in straight lines, did not appear readily reconcilable with a wave spreading out in all directions. To be sure, the bending of light around an object (diffraction) had been recently discovered by Grimaldi, but it was regarded as an effect of the second order relative to the rectilineal passage of light. (Newton's explanation was based on some sort of attraction or of repulsion of light by the edges of objects). The error of this reasoning was not in regarding the small magnitude of the deviation as less important than the propagation in a straight line; that was correct. The mistake consisted in looking upon the principle underlying the one as inferior to that underlying the other. This was rectified by Thomas Young and by Augustin Fresnel. They postulated one principle, namely, that waves of light interfere. This was shown to be sufficient to describe, indirectly, both rectilineal propagation and diffraction. The Frenchman, Arago, helped Fresnel clinch the argument

by some brilliant experiments in proof of the undulatory theory. But still the corpuscular hypothesis had its adherents. Not until 1850 were these also compelled to abandon that once indisputable stand. In that year Foucault performed an experiment, previously suggested by Arago. The *experimentum crucis* was this: to measure the velocity of light in an optically dense medium, and also in one less dense. For according to the emission theory it was greater in the former case; according to the undulatory hypothesis, smaller. The velocity of light was found to be greater in air than in water—and the corpuscular theory then became a subject of historical interest only. It had met its death-blow—so everyone said. Meanwhile, the phenomenon of electromagnetism, the connecting link between electricity and magnetism, had become known through the researches of Oersted and of Faraday. And about 1864 one of the elegant pieces of work in mathematical physics was published. It identified the waves of light with electromagnetic disturbances in the all-pervading ether. This was mainly a prophecy. The reason we point to it with pride is because it was fulfilled. In 1888, Hertz detected the electromagnetic waves emitted by an oscillating electric charge as predicted by Maxwell. Thus continuity was established for light as well as for electricity. Moreover, the possible unity of the physical world loomed in sight—a unity descriptive in terms of a continuous ether (cf. effect of relativity given above). The success of physics as a science seemed too good to be true—and it was. The builders had neglected a stone. It was this rock upon which the investigations of Bohr were founded. We refer to the existence of a "line-spectrum".

The identity of the colors of the rainbow and those formed by the edges (a prism) of a piece of glass must have been known a long time ago. Indeed, Seneca mentioned it in the first century of the Christian era. But not until 1802 were dark lines first noticed in the solar spectrum (the colored bands seen when sunlight, i.e., white light, is dispersed by a prism). Deceived by the plausibility of his own interpretation of these as the boundaries of the different colors, the discoverer, Wollaston, left this field practically untouched for another's genius. And it was Fraunhofer who found not only the dark lines, but also in the case of light from certain other incandescent substances, bright lines without the continuous background. These line-spectra were later shown to be characteristic of an element—the dark lines, due to absorption, being merely a reversal of the same bright ones. For example, hydrogen has four lines in the visible part of the spectrum. The search for a law that would give the respective places of these lines in the spectrum, i.e., their wave-lengths, resulted in a notable contribution to modern physics. J. J. Balmer, a teacher in a secondary school at Basel, discovered the law and expressed it in a very simple form. It was the theoretical deduction of this formula from a modified type of Rutherford's nuclear atom that constituted Bohr's singular success in 1913. We will now examine his work more closely.

The Atom Model

An atom of hydrogen is to be pictured as an electron revolving about a nuclear positive charge—a miniature planetary system. Such an electron will have an acceleration; therefore, according to electrodynamics, it will radiate energy in the form of electromagnetic waves. But this light, (in the broader sense of the word, light includes invisible radiation as well as visible), will be of different wave-lengths depending upon the different frequencies of revolution acquired, as the negative particle spirals into the attracting nucleus. Hence, a continuous spectrum will be emitted. In order for discrete lines to be possible, the classical theory must obviously be modified or disregarded. Bohr did the latter. He subjected the electron to two new *a priori* conditions in direct defiance to the former requirements. Thus a breach was made between classical electrodynamics and spectroscopy. It was widened by extensions of these postulates in meaning and in usage—much to the embarrassment of modern physicists. For the classical theory explains elegantly interference-phenomena but not line-spectra. On the other hand, Bohr's theory interprets equally well line-spectra but not interference. Must physicists abandon their hope of the monistic philosophy that seemed already apprehensible at the close of the last century? How else can the present dualism be regarded? The experimental physicist turns anxiously away from these questions to search for unrevealed truths in nature, that medley of our sense-perceptions; the theoretical physicist seeks safety in spaces of n-dimensions and in clouds of statistical probabilities. Meanwhile, the metaphysician is forced to "light a Murad"—and wonder.

There was one other difficulty in the application of classical physics to Rutherford's model. Radiation and possible collisions rendered such a system of electric charges unstable. But if there is one fact definitely known about atoms, it is their stability. Bohr executed a stroke of genius when he selected the very weakness of the previous attempt for the foundation of his theory. He postulated that the electron should not radiate while in any one of a group of orbits chosen from those dynamically possible. The stability of the atom was then explained by the staying of the electron usually in such an orbit—termed a "stationary state" of the atom. He further endowed the electron with the attribute of jumping from one orbit to another—an idiosyncracy of the negative charge. During such a transition light would be emitted or absorbed with a frequency proportional to the difference of the energies between the two states. Hence, the atom might be considered symbolically, as a set of energy-values corresponding to the possible states—the wavelength of the light emissible to be given by the combination of any two of these terms. This was in accord with the general spectroscopic rule announced in 1908 by Ritz as the principle of Combination. Such were Bohr's postulates—with one addition. He identified the constant of proportionality of the dependence of the frequency upon the energy-difference with a number h introduced by Max Planck in 1900. And this takes us back to the origin of the quantum theory.

The Origin of the Quantum Theory

"Black-body-radiation" (so-called because it is the same as that emitted at the specified temperature by a non-reflecting, i.e., black, body) is that condition of heat radiation which comes about in a space enclosed by bodies of any kind, but at the same steady temperature. Therefore, like temperature and entropy, it has to be calculated by statistics, the method which enables us to determine the average result of many individual events unknowable separately. By means of statistical calculations based on the classical theory, Planck made many attempts to derive a law for black-body-radiation compatible with empirical results. For the existent one of Rayleigh and Jeans did not agree with experiment for short wave-lengths or low temperatures. Moreover, this was theoretically known to be false because it implied an infinite, total energy-density—a physical absurdity. Finally, Planck left the beaten track and took a step in an entirely new direction. He enunciated the following principle: the energy of radiation of any frequency can be emitted and

absorbed only in whole multiples of an elementary bundle of energy, called the quantum. The latter was postulated equal to the product of the frequency and a constant h, which is known as Planck's quantum of action (its dimensions, energy $\times$ time, the same as those belonging to the action defined in the Principle of Least Action). And so we now have a physical quantity energy (in term of h and the frequency), or action (in term of h alone), that is undeniably discontinuous. Is there any relation between this discontinuity of radiation and the elementary unit of charge embedded in continuity? We will return to this question later.

In 1905 Einstein extended the use of the quantum to include visible radiation. For he was thus enabled to account for the previously inexplicable dependence of the velocity of photo-electrons on the frequency of light rather than on its intensity. (Hertz and Hallwachs had established the fact that metals subjected to a beam of ultra-violet light, emitted electrons, which were therefore named photo-electrons). It was ten years before Einstein's equation was experimentally verified by Millikan as a quantitative expression of the photo-electric effect. By that time Bohr had already extended Einstein's use of the light-quantum, as shown above.

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The danger of diverging from a one to one correspondence between the sensible world of experience and the conceptual world of physics is that one may stray too far from the truth. One may be led to make conclusions which are quite incompatible with facts. The recollection of this philosophical aphorism gave rise to the first successful reconstruction of the quantum theory. For the reality of the Fourier components

by some brilliant experiments in proof of the undulatory theory. But still the corpuscular hypothesis had its adherents. Not until 1850 were these also compelled to abandon that once indisputable stand. In that year Foucault performed an experiment, previously suggested by Arago. The *experimentum crucis* was this: to measure the velocity of light in an optically dense medium, and also in one less dense. For according to the emission theory it was greater in the former case; according to the undulatory hypothesis, smaller. The velocity of light was found to be greater in air than in water—and the corpuscular theory then became a subject of historical interest only. It had met its death-blow—so everyone said. Meanwhile, the phenomenon of electromagnetism, the connecting link between electricity and magnetism, had become known through the researches of Oersted and of Faraday. And about 1864 one of the elegant pieces of work in mathematical physics was published. It identified the waves of light with electromagnetic disturbances in the all-pervading ether. This was mainly a prophecy. The reason we point to it with pride is because it was fulfilled. In 1888, Hertz detected the electromagnetic waves emitted by an oscillating electric charge as predicted by Maxwell. Thus continuity was established for light as well as for electricity. Moreover, the possible unity of the physical world loomed in sight—a unity descriptive in terms of a continuous ether (cf. effect of relativity given above). The success of physics as a science seemed too good to be true—and it was. The builders had neglected a stone. It was this rock upon which the investigations of Bohr were founded. We refer to the existence of a "line-spectrum".

The identity of the colors of the rainbow and those formed by the edges (a prism) of a piece of glass must have been known a long time ago. Indeed, Seneca mentioned it in the first century of the Christian era. But not until 1802 were dark lines first noticed in the solar spectrum (the colored bands seen when sunlight, i.e., white light, is dispersed by a prism). Deceived by the plausibility of his own interpretation of these as the boundaries of the different colors, the discoverer, Wollaston, left this field practically untouched for another's genius. And it was Fraunhofer who found not only the dark lines, but also in the case of light from certain other incandescent substances, bright lines without the continuous background. These line-spectra were later shown to be characteristic of an element—the dark lines, due to absorption, being merely a reversal of the same bright ones. For example, hydrogen has four lines in the visible part of the spectrum. The search for a law that would give the respective places of these lines in the spectrum, i.e., their wave-lengths, resulted in a notable contribution to modern physics. J. J. Balmer, a teacher in a secondary school at Basel, discovered the law and expressed it in a very simple form. It was the theoretical deduction of this formula from a modified type of Rutherford's nuclear atom that constituted Bohr's singular success in 1913. We will now examine his work more closely.

The Atom Model

An atom of hydrogen is to be pictured as an electron revolving about a nuclear positive charge—a miniature planetary system. Such an electron will have an acceleration; therefore, according to electrodynamics, it will radiate energy in the form of electromagnetic waves. But this light, (in the broader sense of the word, light includes invisible radiation as well as visible), will be of different wave-lengths depending upon the different frequencies of revolution acquired, as the negative particle spirals into the attracting nucleus. Hence, a continuous spectrum will be emitted. In order for discrete lines to be possible, the classical theory must obviously be modified or disregarded. Bohr did the latter. He subjected the electron to two new *a priori* conditions in direct defiance to the former requirements. Thus a breach was made between classical electrodynamics and spectroscopy. It was widened by extensions of these postulates in meaning and in usage—much to the embarrassment of modern physicists. For the classical theory explains elegantly interference-phenomena but not line-spectra. On the other hand, Bohr's theory interprets equally well line-spectra but not interference. Must physicists abandon their hope of the monistic philosophy that seemed already apprehensible at the close of the last century? How else can the present dualism be regarded? The experimental physicist turns anxiously away from these questions to search for unrevealed truths in nature, that medley of our sense-perceptions; the theoretical physicist seeks safety in spaces of n-dimensions and in clouds of statistical probabilities. Meanwhile, the metaphysician is forced to "light a Murad"—and wonder.

There was one other difficulty in the application of classical physics to Rutherford's model. Radiation and possible collisions rendered such a system of electric charges unstable. But if there is one fact definitely known about atoms, it is their stability. Bohr executed a stroke of genius when he selected the very weakness of the previous attempt for the foundation of his theory. He postulated that the electron should not radiate while in any one of a group of orbits chosen from those dynamically possible. The stability of the atom was then explained by the staying of the electron usually in such an orbit—termed a "stationary state" of the atom. He further endowed the electron with the attribute of jumping from one orbit to another—an idiosyncracy of the negative charge. During such a transition light would be emitted or absorbed with a frequency proportional to the difference of the energies between the two states. Hence, the atom might be considered symbolically, as a set of energy-values corresponding to the possible states—the wave-length of the light emissible to be given by the combination of any two of these terms. This was in accord with the general spectroscopic rule announced in 1908 by Ritz as the principle of Combination. Such were Bohr's postulates—with one addition. He identified the constant of proportionality of the dependence of the frequency upon the energy-difference with a number h introduced by Max Planck in 1900. And this takes us back to the origin of the quantum theory.

The Origin of the Quantum Theory

"Black-body-radiation" (so-called because it is the same as that emitted at the specified temperature by a non-reflecting, i.e., black, body) is that condition of heat radiation which comes about in a space enclosed by bodies of any kind, but at the same steady temperature. Therefore, like temperature and entropy, it has to be calculated by statistics, the method which enables us to determine the average result of many individual events unknowable separately. By means of statistical calculations based on the classical theory, Planck made many attempts to derive a law for black-body-radiation compatible with empirical results. For the existent one of Rayleigh and Jeans did not agree with experiment for short wave-lengths or low temperatures. Moreover, this was theoretically known to be false because it implied an infinite, total energy-density—a physical absurdity. Finally, Planck left the beaten track and took a step in an entirely new direction. He enunciated the following principle: the energy of radiation of any frequency can be emitted and

absorbed only in whole multiples of an elementary bundle of energy, called the quantum. The latter was postulated equal to the product of the frequency and a constant h, which is known as Planck's quantum of action (its dimensions, energy $\times$ time, the same as those belonging to the action defined in the Principle of Least Action). And so we now have a physical quantity energy (in term of h and the frequency), or action (in term of h alone), that is undeniably discontinuous. Is there any relation between this discontinuity of radiation and the elementary unit of charge embedded in continuity? We will return to this question later.

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of the classical theory had long been the subject of dispute owing to their non-observability. Moreover, they did not yield the frequencies given by Ritz's Combination-Principle. Consequently W. Heisenberg proposed to make the observable ones the basis of a new presentation. The position q and the momentum p (mass $\times$ velocity) were to be expressed, somehow, in terms of these frequencies. Since the latter depend upon the combination of any two terms of a series, they can be put in the form of a two-dimensional table. The consideration of such an aggregate as a matrix enabled Heinsenberg to develop a different method of quantization. This theory is called the New Quantum Kinematics.

The exact nature of the array of terms was a square matrix of infinite order. The peculiar fact about such mathematical expressions is that their multiplication is non-commutative, i.e., pq is not equal to qp. The new quantum condition was given by the setting of the commutator (pq — qp) equal to $\frac{h}{2\pi}\frac{I}{\sqrt{-1}}$ (I is the so-called unit matrix). This was analogous to the previous one, not only in form, but also in usage. It served to condition the solutions of Hamilton's canonical equations of motion. And in this way, the theory was applied.

The outstanding success of the New Quantum Kinematics was that it yielded from its inherent qualities the half-integral quantum numbers, so much desired. To be sure, this did not solve the mystery of the nature of the quantum. But the very indefiniteness of the new conception—or was it hope?—kept people from demanding definite answers. The applications of Heisenberg's method were even more successful than the previous one, especially in regard to the estimation of intensities. But the mathematical trickery necessary to wheedle most of the solutions out of the fundamental equations made many believers in simplicity shudder. From all indications, the physical laboratory would soon appear like the office of an actuary, rather than the work-shop of a scientist.

As we look back over the past five years, since the inception of this theory, we see its importance dwindling. In the light of recent progress the value of Heisenberg's work has taken on a different glow. Psychologically, its strength lay in pointing theorists to new paths; philosophically, in the dictum about the non-observability of such commonplaces as the position, the velocity, and the frequency of an electron. But above all, its strength was in its logical inclusions of Bohr's frequency-condition and of his Correspondence-Principle. Certainly such a contribution is inestimable.

In the same year (1925) that the preceding theory was given, a very similar one was published by P. A. M. Dirac. He used a mathematical entity called a q-number as his basis. The noteworthy feature of this concept was that it could sometimes be identified with pointer-readings, and sometimes not—provided no questions were asked as to when or why. Such an extension of the nature of the mathematico—physical word is pregnant with possibilities—and novel, to say the least. The actual formulation and results of this theory, however, were almost identical with those of Heisenberg.

The development of a different algebra was not the only attempt to gain a new conception of the atom. Several months after the work of Dirac, E. Schrödinger presented a scheme which has proved to be more valuable than any of the foregoing. By means of a variational proof, that is convincing to few, he obtained a differential equation which is fundamentally significant, regardless of its derivation. He showed that only a certain number of energy-values ("characteristic values") satisfied the equation if its solutions were subjected to several assigned boundary-conditions. And these were identical with the values of energy belonging to the stationary states of the previous theories. In this way quantization was reduced to the problem of setting up a differential equation and solving it—in many cases a type well-known to mathematicians. The ease of such a method in comparison with the complicated algebra of matrices—to say nothing of rigor—made the adoption of Schrödinger's theory just a matter of time. Since the basic equation involved the energy, this presentation became known as the "New Quantum Mechanics" in contrast with the kinematical innovation of Heisenberg.

Born and Wiener had shown that the matrix mechanics could be formulated by the consideration of the coördinate and the momentum of the electron as operators; namely, as a multiplier and as a differentiating factor, respectively. Using this interpretation, Schrödinger was able to point out a relation between his theory and that of Heisenberg. In fact, he showed a means of deriving the latter's matrices from the characteristic functions of his own equation. Thus the two theories could be looked upon as equivalent mathematical methods of quantization.

Buoyed up by the hope of deriving the new equation from classical electrodynamics by some additional postulate, physicists have demurred from accepting Schrödinger's interpretation of it. This is couched in an almost speculative theory of matter published in 1924 by Louis de Broglie. The latter proposed that any piece of matter, as an electron,—or yourself—should be represented by a periodic function defined continuously in space except at one place, a singularity at its observed position. Moreover, the frequency should be considered as having variations within definite limits. On such a hypothesis a particle at rest consists in a set of stationary waves stretched across space. If it moves, however, these become progressive waves; and their group velocity is nothing more than the mechanical velocity of the particle —provided that the product of this and the original velocity is taken equal to the velocity of light squared (suggested by the principle of restricted relativity). Furthermore, the wave-equation of geometrical optics was shown to be analogous—some use the word identical—to the Hamilton-Jacobi partial differential equation of higher dynamics. And incidentally, Fermat's Principle was proved equivalent to Maupertuis' Theorem. But the first of these (in each instance) deals only with light considered as propagated along rays. For diffraction-phenomena, where the concept of the wave is absolutely necessary, a different wave-equation has to be used—that of physical optics. Should there not be another corresponding, mechanical wave-equation—suggesting the diffraction of matter? An interpretation of Schrödinger's equation in this manner was given. And thus evolved the subject of Wave Mechanics, which treats of particles as "material" waves.

Perhaps a clearer understanding of the meaning of Schrödinger's equation can be gained by the consideration of an analogous one in acoustics. For example, take the case of a distorted stretched string, infinitely long. A quasi-wave-equation can be derived to describe its motion. This may represent a distortion of the string, which travels continually and indefinitely along the string with a constant speed. However, no restriction is placed upon the wave-length of the vibrations or upon the simultaneity of the existence of different ones. This occurs only when boundary conditions are imposed—or in the language of the

(Continued on Page 31)

Diesel-Electric Locomotive Development

The Development of the High Speed Diesel Engine has Made Possible the Application of the Diesel Engine to Locomotives.

By Herbert T. Herr, '99S.

THE recent rapid advance in the development and application of the oil engine, especially to marine installations, makes consideration of its use in other fields an attractive study.

The extremely high thermal efficiency of the Diesel engine has always been its outstanding feature. It is logical that the practical development of this type of prime mover should have been closely allied with ship propulsion, because propeller revolutions are of a low order in low speed ships, and hence well suited to reciprocating engine drive, while machinery weight and space are not deterrent factors in that class of vessel. Efficiency in fuel consumption, however, is all-important.

The conventional ship propulsion machinery of twenty or thirty years ago (the formative period of Diesel engine development) was the reciprocating steam engine. The Diesel engine being of this general type, fitted in well with the traditions of

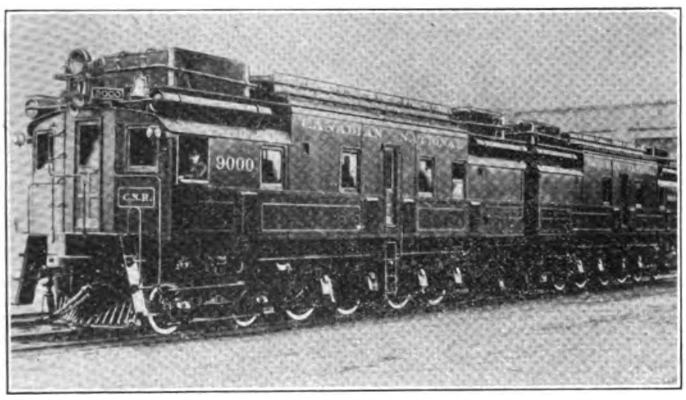

Fig. 1. The Diesel-Electric passenger locomotive built for the Canadian National Railways by Westinghouse.

the shipbuilding industry, and its efficiency in operation outweighed its high first cost.

An examination of Lloyd's Register indicates that in the last twelve years, motor-driven vessels have increased from 7,500 tons to 812,000 tons, and that in this period the percentage of new tonnage fitted with propelling machinery using Diesel engine drive has increased from 2% to 43%. Remarkable as this progress has been, we have only to remember that the gas engine, using as it does a relatively high-priced fuel like gasoline, has driven from our city streets and highways all other forms of power generation for transportation. The reason for this is axiomatic, namely, for any given application, that type of machinery will prevail which, all things considered, gives the highest economic value in operation.

In railway transportation, improvements in motive power have perhaps been responsible for the greatest reduction in costs, and yet the steam locomotive, which still predominates on the railway, is relatively a very inefficient heat engine, because it is not practicable to operate it as a condensing steam engine. A very large amount of its heat energy is therefore wasted by atmospheric exhaust, whereas the steamship can take advantage of the condensing cycle of operation in the steam engine or turbine to economically utilize its fuel.

Great progress has of course been made in the past twenty years in the development of the steam engine and steam turbine from the viewpoint of efficiency. This progress is almost entirely due to our ability to increase the temperature range of the engine cycle and its rotative speed, but even with the most modern attempts at high duty in the steam engine or turbine of the condensing type, it has not been possible to closely approximate the Diesel engine, the efficiency of which is primarily due to the very great range of temperature in its working cycle.

These general considerations have greatly interested the railway engineering fraternity. In the earlier developments of the Diesel engine it was not practicable to install this type of machinery within the limits of weight and space available in railway traction, and the difficulties of transmitting the power from the Diesel engine to the running gear of the locomotive constituted a serious mechanical problem.

I remember quite well in my undergraduate days at Yale the description of Diesel's early work, and the distinct impression, in the study and teaching of thermodynamics, that no prime mover for the production of power could offer such high efficiency as the Diesel cycle. The gas engine cannot approach it because of its limitation of compression pressure fixed by the phenomenon of pre-ignition, which must be avoided during the compression stroke of the piston.

The gas engine relies for its operation on a limited compression ratio to prevent ignition of the fuel until is is fired at or

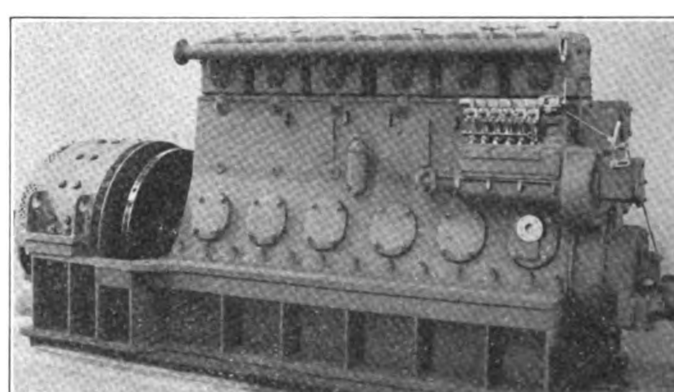

Fig. 2. A high-speed Diesel engine designed for rail-car service which develops 400 H. P. at 1,000 R. P. M.

near dead center by an electric spark. In the Diesel engine the compression of pure air cannot be limited otherwise than by making the ratio such that the temperature is high enough to

From a paper presented at the recent banquet of the Yale Engineering Association at New York.

cause spontaneous burning of the fuel injected at or near the dead center after compression is practically completed.

Notwithstanding its unquestioned efficiency, the progress of the Diesel engine was greatly retarded because of the difficulties of design and construction, resulting from the high pressures and temperatures necessary in its operation. Its field of usefulness was therefore narrowed considerably, and, as I have said, found its best application in marine work.

In railway traction the width and height of a locomotive are limited to the operating clearances of the right-of-way. In America these clearances are approximately 5½ feet each side of the center of the track and 16 feet above the rails. While running gears of locomotives vary considerably as to height of the driving wheels above the rails, the maximum height is found in high-speed engines for passenger service, where large driving wheels are desirable.

With the rapid increase in tonnage of passenger and freight trains on our railways and the continual demands for shortened time schedules between terminals, the requirements for power from the locomotive have increased so greatly that it has taken all the skill and ingenuity of our great motive power engineers and locomotive builders to design and construct machines to meet these demands, and the locomotive boiler has become the limiting factor in the production of steam locomotives of high horsepower.

It is quite apparent, with the limited clearances of the railway right-of-way, that the boiler or internal combustion engine of a locomotive must be placed above the driving wheels. Also, if internal combustion engines are to be used for the generation of power, this power must be transmitted to the locomotive running gear. This problem has been very successfully worked out in automobile practice with gearing, but gearing does not apply well to the higher powers required in locomotive practice.

The internal combustion engine is very much less flexible than the steam engine, and while attempts have been made to couple oil engines directly to the driving wheels in a manner similar to steam locomotives, such an arrangement has been found entirely impracticable. A variable speed transmission is therefore necessary.

Many forms of transmission have been suggested and tried, such as compressed air, compressed gas, hydraulic, geared and electric, but none has worked out as successfully for the high powers needed in locomotives as the electric form, that is, the engine drives an electric generator, the current from which is used in the electric traction motors direct-connected or geared to the driving wheels, the former being located above the deck of the locomotive and the latter below it.

This form of transmission, while not as efficient as direct gearing, has the great advantage of complete flexibility, which permits, if desirable, the operation of the oil engine at constant speed.

The application of motors and control apparatus to electric traction has been so thoroughly developed that there are no serious problems to be overcome in transmitting the power of a Diesel engine to the running gear of a locomotive electrically. In fact, it has been found that electric traction has very desirable characteristics for locomotive purposes, and commercially, electric traction has been used from the smallest to the largest powers with entire satisfaction in the operation of various kinds of traction vehicles. That part of the problem, therefore, is completely solved by the adoption of electric drive, and there remains only the construction of the Diesel engine in such form that it may be applied within the limited clearances and reliably operated in traction work to realize the benefits which may be derived from oil-electric locomotives.

It is apparent from what has preceded that the first requisite of the Diesel engine for locomotive purposes is that it can be carried on the deck of the locomotive above the running gear, within the allowable clearances of the right-of-way.

Road locomotives vary considerably in power output. They range say from 600 horsepower to 2,500 horsepower. The average steam engine generally seen on our railroads will not much exceed 1,000 horsepower continuous output, and 3,000 horsepower rating represents the largest steam locomotive built.

The available space for the emplacement of power-generation machinery of the Diesel type is taken as 9 feet 6 inches wide and 9 feet 6 inches above the deck of the locomotive.

Some seven or eight years ago William Beardmore & Company, of Glasgow, Scotland, undertook for the British Air Ministry the development of an oil engine for application to aviation. This development was carried on over a period of years and resulted in a 4-cycle single-acting engine in which every endeavor was made to reduce weight by the use of special materials and to obtain maximum output from a given size cylinder by great increase of rotative speed. This development has yielded a commercial Diesel of some 300 to 400 horsepower, running at 800 to 1,000 r.p.m., with piston speeds of 1,600 to 2,000 feet per minute. This engine as built by the Westinghouse Electric & Manufacturing Company weighs eighteen pounds per horsepower and is illustrated in *Figure 2*. A number of these engines of four, six and eight cylinders were purchased by the Canadian National Railways for application to rail car service, the cars being operated by electric traction. These cars have now been in operation over four years and have shown very excellent economy.

The Canadian National Railways were anxious to undertake a more comprehensive electrification of their lines by Diesel-electric locomotives and laid down for this purpose a locomotive of approximately 2,700 horsepower, comprising two cabs operated in multiple with an oil engine generator set in each cab. The contract for these locomotives was taken by the Westinghouse Electric & Manufacturing Company, collaborating with the Canadian National Railways, the Baldwin Locomotive Works and the Beardmore Company, the Westinghouse Company having previously acquired rights from the Beardmore Company for its Diesel engine developments.

A study of the Canadian National Railway conditions indicated a favorable try-out for this locomotive in the railroad's transcontinental passenger service between Montreal and Winnipeg, a distance of approximately 1,000 miles.

The steam locomotives handling this transcontinental passenger traffic are operated over divisions of approximately 200 miles. The number of steam locomotives assigned to this service is twenty-six. An analysis of the transportation conditions showed that with locomotives such as the Westinghouse Company proposed to build, six would handle the same service, effecting considerable economies in operation. The trial locomotive has been constructed and put in operation and shows very good results in the way of economy. As constructed, with its generator, this engine is 21 feet long, 8 feet 6 inches high, and 4 feet 6 inches wide, and can therefore be installed in the 9 feet 6 inches cab.

During the period of development by the Beardmore Company, the Westinghouse Electric & Manufacturing Company

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How the Organic Chemist Aids Medicine

The Organic Chemist Plays an Important Part in Extracting and Purifying Natural Occurring Substances Used in Medicine and in Synthesizing Valuable Drugs.

By Professor D. T. Keach.

IN the entire range of modern scientific discovery and development no phase is more interesting or more important for the welfare of mankind than the advances made in the healing art. Both the physical and biological sciences contribute to this work, but the part of the chemist, and especially of the organic chemist, is very significant.

It is probably true that the average person whose major interests lie outside the field of chemistry knows very little about the methods of procedure by the use of which the organic chemist has succeeded in making available a large number of medicinal products. It is the purpose of this paper to give information regarding this fascinating subject.

In general there are two sources of these organic medicaments;—(1) they may be obtained from materials occurring in plants and animals, or (2) they may be secured by the synthesis of compounds of a character that has been found to have definite, and desirable, physiological action. In an increasing number of cases it is being found possible to change from the use of natural occurring materials to the same substances made synthetically.

In 1855 Addison published his observations on the disease which has since borne his name in which he stated that he could find no evidence of organic changes anywhere in the bodies of the victims of the disease except in the suprarenal glands. The study of the physiological functions of the suprarenal glands dates from his discovery. As a result of this study it was found that in these glands there is a substance, adrenaline, which has the power of constricting the blood vessels, and raising very markedly the arterial blood pressure. The material was first secured as an extract from the suprarenal glands of animals, usually sheep, but this extract contained other substances as well. To obtain the active substance, or principle, in the pure condition offers to the chemist one of his greatest problems. It must be freed from all other substances, and the operations by means of which this is done must be such as to do no injury to the desired product; that is, cause no change in chemical constitution. This means that the reagents used must be those which do not decompose the substance, and if heat has any effect on it, a method of procedure must be found which will make it possible to work at a sufficiently low temperature to obviate this danger. Sometimes this separation of the principle in the pure condition presents such difficulties that years are spent on the work and in many cases chemists have not yet been successful in their efforts.

When the pure material is secured it is analyzed to find what elements are present, and in what proportions by weight they occur. This part of the task is quite simple compared to the other problems presented to the chemist.

The work of analysis is followed by the determination of the constitution, or structure, of the compound; that is, it must be determined in what manner the atoms are placed with respect to each other in the molecule. This is possible for the chemist, because of his knowledge of the general reactions of the different types of organic compounds. However, it frequently offers great difficulty, and takes much time for its solution. When this is accomplished, it is possible to write the so-called graphic formula of the pure substance. By the use of such means the graphic formula of adrenaline was shown to be

$$\begin{matrix} HO \diagdown \\ HO \diagup \end{matrix} C_6H_3CH(OH)CH_2NHCH_3.$$

Once the formula of the compound is known, the chemist attempts to produce it synthetically; this again being dependent on a thorough knowledge of organic reactions. In the case of adrenaline several satisfactory methods of synthesis, starting with simple materials, have been found. In general the synthetic method is a much simpler way of obtaining the desired compound than the extraction from the natural occurring source. Consequently it can be secured in larger amounts at less cost.

Years ago, it was noted that the oil extracted from the chaulmoogra nut had a somewhat beneficial effect on leprosy. It caused, however, disagreeable digestive disturbances and for this reason was not much used. Comparatively recently Dean and his co-workers separated the oil into fractions by the process of fractional distillation. Lepers were treated with the various fractions and all except one were found to have no effect whatever. The fraction which was effective was much more so than the oil in its entirety; this fraction contains the active principle. A partial determination of the structure of this substance, has made it possible to make a slight alteration in composition which still further enhances its value.

Several years ago it was reported that over one thousand cases had been cured in the leper colony in the Philippine islands, and in a recent number of "The Yale Review" the following quotation relative to a leper asylum appears in an article on India:—"The chaulmoogra oil injections are regularly given to the lepers with, it is said, eighty percent success complete or partial in recent cases, and less success in advanced cases. But it is claimed that the ravaging progress of the fell disease is arrested even in the advanced cases." One English doctor has predicted the disappearance of the disease in fifty years.

The case of cocaine is interesting. This drug is obtained from the leaves of a plant, coca erythoxylon. The followers of Pizarro found the natives of Peru chewing the leaves of this plant to avoid fatigue and to dull the pangs of hunger. For a long time it has been used as a local anaesthetic, but it is a poison, and its use was too frequently attended with dire results. Secured in the pure condition, its graphic formula was found to be

$$\begin{array}{ccccc} CH_2 & — & CH & — & CHCO_2CH_3 \\ | & & | & & | \\ | & & NCH_3 & & CHOCOC_6H_5 \\ | & & | & & | \\ CH_2 & — & CH & — & CH_2 \end{array}$$

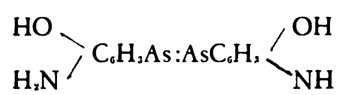
Efforts were then directed to the finding of the active part of the molecule, by what was essentially a process of splitting off parts of it, and by tests showing what portions were indispensable. This resulted in the discovery that a definite arrangement of cer-

tain groups of atoms, relative to each other, was necessary. Consequently a substance, novocaine, having the formula

$$NH_2C_6H_4CO_2CH_2CH_2N(C_2H_5)_2,$$

was prepared and found to have excellent local anaesthetic action, while it possessed only one-seventh of the toxicity of cocaine. Other satisfactory local anaesthetics have also been secured synthetically.

Ehrlich knew that the inorganic compounds of arsenic were deadly to the trypanosomes, which, when present in the blood, cause syphilis, but, unfortunately, the same compounds are deadly to man. The problem, he reasoned, was to find a more or less complicated organic compound of arsenic, which should be fatal to the trypanosomes, but harmless to man. With the aid of his co-workers, he produced 606 compounds of arsenic. Salvarsan, the last to be produced, proved to have the desired qualities to a considerable extent. Many cures have resulted from the use of this drug, but it is not a perfect remedy, and the search for compounds of arsenic, and also of mercury, for the treatment of this disease continues. The formula of salvarsan is written



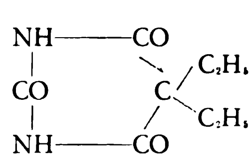
The important principle, insulin, obtained in an impure form from certain glands of sheep, is one of the more recent successes in this field.

Another contemporary development is the work being done on the tubercle bacillus (much of it at Yale under the direction of Professor T. B. Johnson). It having been found possible to grow the germs in large quantities on artificial media, the attempt is being made to discover all the chemical compounds present in the organism, and to secure, if possible, a complete understanding of the chemistry responsible for the development of the disease. Such a complete knowledge of the chemistry of the living germ may indicate the method of providing the cure of this malady. And it is almost certain that the production of this cure will demand the creative skill of the organic chemist.

A brief discussion of some work on sleep-producing drugs, hypnotics, may indicate more clearly the method of the organic chemist in synthetic work, and incidentally some of the rebuffs which it is his lot to meet. The compound phenyl methyl ketone, of formula

$$C_6H_5COCH_3,$$

having been found to possess sedative action, and it being decided, for excellent reasons, that this action was largely connected with the CO group of atoms in the molecule, other compounds containing this group were tested. Thus, in time, a number of useful drugs of this type were discovered. Of these veronal, has the formula



Now it is possible to make a large number of modifications of this molecule, and since the substance, veronal, is not free from

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OUR CONTRIBUTORS

Dean Charles Hyde Warren of the Sheffield Scientific School, who writes about the history of South Sheff., graduated from Yale in 1896. He took his Ph.D. at Yale in 1899 and went to Massachusetts Institute of Technology the following year, where, besides teaching, he was Chairman of the Committee on Courses of Instruction. He was also actively engaged in work on abrasives and ceramic materials. He became Dean of the Scientific School in 1922. He has published many scientific papers and since 1926 has served on the committee which conducts the affairs of the American Journal of Science. He holds the position of Sterling Professor of Geology.

Prof. Raymond John Seeger, who writes on the Quantum Theory, went to Rutgers University, where he took his B.A. in 1926. He came to Yale to do graduate work in Physics. In May 1928 he won the F. E. Loomis Fellowship, which is awarded for the best competitive examination in Physics. He was given his Ph.D. degree last year. The subject of his paper was: "A Critique of Recent Quantum Theories." He is a member of Phi Beta Kappa and Sigma Xi. He is now an Associate Professor of Physics in the Presbyterian College at Clinton, S. C.

Mr. Herbert Thacker Herr, whose article on Diesel Electric Locomotives appears in this issue, received his B.S. degree in E.E. from Yale in 1899. He was a member of Delta Phi, and Sigma Xi. He is now General Manager of the Westinghouse Machine Co.

He began his engineering career by joining the Denver and Rio Grande Railroad and after several years was appointed general superintendent. He joined the Westinghouse Machine Company in 1908, becoming General Manager and continuing in that capacity until 1915 when he was made Vice-President of the Westinghouse Electric and Manufacturing Company.

DeWitt Talmage Keach, the author of the article on the relation of organic chemistry to medicine, graduated from the Sheffield Scientific School in 1915 and received his M.S. from Pennsylvania State College in 1917. There he acted as instructor in chemistry from 1915 to 1918, when he became Assistant Professor. In this capacity he remained till 1920. In 1923 he received a Ph.D. degree from Yale and in 1925 he was made Assistant Professor of Chemistry at Yale.

Mr. Samuel S. Board, who wrote the article on the opportunities of engineering graduates, graduated from Yale in 1911 and received his B.A. degree. He has also received a M.A. degree. Mr. Board studied industrial processes at Columbia in 1912-13, and the next fall spent three months teaching at St. Bernard's School in New Jersey. In 1922 he wrote a series of weekly articles entitled "On the Job" for the Daily Review of Nassau County and three weeklies. Mr. Board is now the Director of the Yale Graduates Placement Bureau.

Lieutenant Charles George Holle, whose article on Flood Control appears in this issue, is an Assistant Professor of Military Science and Tactics. He attended Ohio Mechanical Institute and the University of Cincinnati. He then went to West Point and Rensselaer Polytechnic Institute. He was also at this time on troop duty with the Second and Eleventh Engineers in Texas and Panama. He came to Yale in 1926. He is an honorary member of Cannon and Castle Society and a member of Sachem Hall and Phi Sigma Kappa Fraternity.

The Challenge of Engineering Today

The Need for Men with the Engineers Vision and Training is Increasing, Due to the Trends of Our Present Day Civilization.

By SAMUEL S. BOARD.

IN January a short statement was published in the Yale Scientific Magazine regarding the need for more engineers—especially those with mechanical or electrical background. This could be supported by a statistical study of present demand and supply. It could be amplified to include a well-calculated prediction as to the needs of the next ten years. Rather than do either of these, the writer has chosen to discuss briefly some of the ramifications and reasons for this demand as they appear to a placement officer.

If this appears to be special pleading for recruits in what is only a phase of modern life, he will have to admit the charge, while emphasizing his belief that the general trend of thought today is such as to make some champion of this method of training both desirable and necessary.

The answer as to why this is so lies imbedded in the characteristics of the age. For good or ill, our lives are bound up in the products and operations of machinery. Our food, our clothes, our books, even to a large extent our pictures, are mechanically derived. Certainly our transportation and amusement facilities are principally dependent on the machine. A good many philosophical writers seem to fear machine domination. R. U. R. and its counterparts have made a profound impression on our thinking. Are we driven and to be driven by these forces which we have set in motion? Are these tools to be the means of enslavement or of freeing the things that are eternal in man? The answer would seem to be not in learning to write cleverly about the matter, necessary as writers are, but rather in learning to control and use the machine. And thus the demand for the engineer.

There were many, during the first industrial revolution, who sincerely believed that the only way to relieve the unemployment caused by the introduction of machinery was to restrict and reduce the use of it, but history has demonstrated, during the past hundred years, that the way to relieve it was to make better machinery—more easily used and more productive per man power—to create new channels of employment through the production of new commodities. Now that we are in the midst or perhaps at the beginning of another industrial revolution, why doesn't the answer lie in the same direction? If it does, progress will be hindered, human welfare retarded, unless we can have the statesman-like help of engineers who are not just glorified mechanics but men who foresee and reckon with the social effects of the work they do as well as the mechanical—not master mechanics alone but masters of machines for the common good. Is this lacking in romance? Is it a degrading or debasing occupation or one lacking in culture? To me it presents one of the profoundest challenges to high thinking that the age affords.

One need only to look over the history of the past ten years to realize how closely machine development is connected with the prosperity and well-being of the country. Every major war is, of course, followed by a fall in commodity prices which has meant a decrease in profits to producers. This period has been no exception. Heretofore, the favorite method of reducing costs to meet this has been a reduction of wages. This, of course, has reduced buying power and so reduced profits still further. At the close of this war, however, some far-sighted and daring industrial leaders—many of them engineers or with the engineering mind—said: "No! This time we will keep wages as high as possible but increase efficiency and reduce the unit costs." Four times, since 1920, this has been attempted and engineers have been called for to do the job. Three times they succeeded, to the amazement of the rest of the world, and they are now at it again. Can they succeed this time? Talk about suspense! The thrill of watching for the signs of success beats that of any romance I've ever read. The politicians who think they are playing doctor to prosperity are kidding themselves. It isn't luck or chance that we have an engineer in the White House today. It's because an engineer is about the only person who could do the job and the American people have had sense enough to realize it.

The extraordinary demand recently for young engineers has been mentioned and is indeed the raison d'etre of this article, but it, perhaps, isn't realized how widespread this demand has become. A few illustrations may indicate the scope. Last spring a representative of a large western bank came in for men—young men who could go in to train as representatives of this bank throughout the country. Among the primary requirements for the position was that the men have an engineering background. It's logical, too, isn't it? Representing a bank located in one of our outstanding industrial communities, they needed to know the background of the securities they handle and the service they rendered. In addition, they needed to know organization, planned thinking and the use of facts as tools. Why not engineers, if they could get them?

Equally interesting was the request for engineers from the Planning Department of a large department store. The head of the department was an exceedingly capable woman but she realized the advantages of having men trained to lay out plans logically—men who could understand something of the mechanical factors involved and who could bring a familiarity with the study of motion and effort in the doing of the task.

The demand for engineers who can and will sell technical products is well known. If we are to have machines and machine-made products, it is somewhat natural that employers should feel that engineers can sell them better. Even such an unrelated field as advertising has to call for them as copy-writers every so often. So, also, we find calls from accounting firms, from trade associations and from almost every phase of human endeavor today except the ministry and medicine. Even the law sometimes calls for a technically-minded man.

One can, of course, see from the preceding that the engineer needed today is anything but the uncouth individual he is frequently supposed to be. High boots and overalls may be necessary under certain circumstances, but the same man must be able eventually to appear before Boards of Directors and assume membership in them. He must be sufficiently cultured to meet

representatives from other countries and, lastly, he must be able to interpret what he is doing to his fellow men. For, if there is any criticism of engineers today, it is their failure to do just this. Reforms today in productive procedure must not only be scientifically and carefully planned but they must, wherever possible, be carried out with the co-operation and aid of the workers. One young engineer, who was engaged in studying the time involved in certain processes of the airplane industry, was fired forthwith because he pulled out his stop-watch while he was back of the operator and without the operator's knowledge. There were naturally some other reasons, also, but they were related to the thoughtlessness and inconsiderateness which allowed him to make such a mistake.

So, again, these products which are constantly being produced anew by chemists and engineers would be of small value unless their use was interpreted by someone. This takes social intelligence, imagination, tact. So, also, with the answering of the question as to what to do with the older people who are laid off because of inefficiency—indeed the inefficient of all ages. Is there any way in which this can be compensated? Such a question is not above the province of the politician, the social worker or the psychologist. It is an engineering matter also. The answering of such questions will require in engineers, however, far more than technical knowledge—it means an understanding of people—a background of sociology and, as has been said before, a statesmanship which can see not only the machine or the man but the machine and the man.

Rather paradoxically, however, our post-war prosperity, which is so largely the fruit of engineering labors, has tended to reduce the supply of engineers. Large numbers of people who never before were not very far from having to think first of food and clothing have turned their attention to more aesthetic things, including the more aesthetic sides of food and clothing. Despite the fact that it seems to have been largely ignored by the press, there are undoubted evidences of a cultural renaissance in the colleges. The wail of a middle western football coach last fall that the undergraduate was no longer interested in athletics was pooh-poohed by the papers but most certainly contained a lot of truth. In addition, we have been showered with other distractions. The automobile as a means of pleasure and communication has come into its own. We have the radio, for good or ill, talking movies and other mechanical means of entertainment. The result seems to be not only an increasing failure to understand just what the engineers of today are doing but a lack of understanding of what work itself means. The emphasis has been on the product and not on the process or the producers. Two years ago, when a group of twenty boys chosen from a representative high school, were asked what they intended to do, one of them was going into engineering, two were going to take business courses, and the rest were going to take academic work in college, because they hadn't decided what they wanted to do.

There is also another factor which has tended to discourage new recruits. We have learned so much in the past few years about the various phases of engineering that the curriculum has tended to become harder and harder as time has gone on, until now it is difficult, in fact impossible in some schools, for a man to do anything else except study and recite. This has been unfortunate in at least two ways. A considerable proportion of college students, between 25% and 50%, today earn at least a part of their expenses at the time they are incurred. Scientific school men find it increasingly difficult to do this. They simply haven't the time. A good many boys who might wish to take up scientific subjects hesitate because they wish to attend a school of college grade and yet must pay at least part of their expenses. Others have undoubtedly been deterred by the feeling that, after all, social affairs are a part of college and desirable, but that, lacking brilliance in mathematics or other scientific subjects, it would be difficult, if not impossible, for them to take any part in extra-curriculum affairs while taking a scientific course. Sheff men have repeatedly disproved this, though perhaps not so much while taking what are usually called straight engineering studies.

More responsible than anything else, however, is the fact that before the war and for a few years after it, there was a surplus of engineers. Partly as a result of this and also perhaps because engineers haven't been so adept at selling their services as some other types of workers, they have been underpaid, especially during the period between their fifth and tenth years out of college. The information has gradually sifted back into the schools where the decision as to what course one is to take must be made. It would be as idle to deny the money motive as to consider it the only one.

All of these factors have had their influence so that at this time when there is a real demand for engineers and a need for them, the supply has been becoming proportionately, if not actually, less. Naturally, this will be overcome in time, but the difficulty is that by the time the minds of boys and their parents, or perhaps of girls, turn again toward scientific training, there will be so many turned this way that another surplus will be created, even in the face of the greatly increased demand. Now is the time when the chances in this general field should be brought home to those who are choosing, rather than two or three years from now.

In doing this, however—and it is our hope that you who are now in college, as well as those who are out, *will* take the word back to your younger brothers, relatives and friends—we must keep in mind that, after all, there are certain fundamental abilities necessary. One must have *some* facility for mathematics and some machine sense if one is to go into mechanical or electrical engineering. In the structural field, an interest in creative activity along this line is desirable and the ability to draft or draw along drafting lines is also of value. To some extent, these interests will grow and develop as young people think of and study the field. If they will only read about it, think about it and investigate it, unsuspected inclinations will be discovered and advantages in other lines of work will not seem so important in comparison with the challenge of this field, which is still primarily a male responsibility and opportunity.

One could wish also, that without reducing in the least the need for real constructive thought and application, the instruction time and study time necessary in the courses leading to an engineering degree might be brought more in line with the time involved in other courses so that the opportunity for self-help, for social intercourse and for recreation would be greater even in the most technical divisions of the scientific schools. We need men badly who know these fields but they must be socially minded as well, able to mingle freely and lead in the multitude of human activities which comprise our modern world.

The Mississippi Flood Control Plan

The "Adopted Project" for the Control of "The Father of Waters"

By CHARLES G. HOLLE, 1st Lieutenant, Corps of Engineers.

THE greatest flood ever recorded by man occurred in the alluvial valley of the Mississippi River in the Spring of 1927. The flood in the section of the valley below Vicksburg was greater than any in previous years. Lives were lost, people were temporarily rendered homeless, and the property damage was said to be large. In addition, there was some economic loss to the country, resulting from the interference with the normal conduct of farming, business, and commerce, the delay in the movement of traffic and the mails, and the financial burden of providing funds for, and the carrying on of, relief work. The losses seemed large, but in comparison with 18,000 lives that are lost every year by automobile accidents, they do not appear so great. In order to protect against a recurrence of disastrous floods in the alluvial valley of the Mississippi, Congress in May, 1928 authorized and provided for the prosecution of a comprehensive plan of flood control known as the "Adopted Project", for which the huge sum of $325,000,000 was authorized.

In order to intelligently consider the economic and the engineering features of the "Adopted Project" it is essential that we be familiar with the characteristics of the Mississippi River and its flood plain, the history of the occupation of the valley by civilized man, the previous efforts of man to control the river, and finally the present problem involved.

The Mississippi is the world's greatest river. Its potential 60,000,000 horse power during flood, unconvertible to man's use, is expended in eroding banks, transporting silt, and driving its own great volume of water from Cairo to the Gulf of Mexico. The maximum measured discharge of the main river channel between levee lines is 2,000,000 cubic feet per second. Unconfined, the flood waters would cover 30,000 square miles. The water shed of the Mississippi includes parts of 31 states. The river's functions of drainage, avenue of transportation and commerce, source of water supply and power, aid to industry and agriculture, and its numerous other useful services, are of vital importance in over 40 per cent of the country's area. Of course, flood control directly affects a smaller percentage of area, as only the lowlands are charged by nature with the easement, by overflowage. During the spring of the year the melting snows and heavy rains and consequent large run-off on all the tributaries creates a flow of water in the lower river in excess of the channel capacity. The river overflows its banks and floods the adjacent territory.

In the course of the centuries this annual overflowing has built the alluvial valley of the Mississippi and created its peculiar topography. The entire valley from Cairo to the Gulf, 600 miles long, 50 miles wide and of unknown depth, has been built by the flooding river depositing the enormous quantities of earth which it has been carrying. The river is extending its valley out into the Gulf of Mexico at a present rate of a mile in 21 years. As the river rises and escapes the confines of its banks the velocity and the dependent silt carrying capacity are both decreased, and the excess silt is deposited. Thus, through the ages the valley has been filled progressively away from the river; the flood plain being built higher and higher adjacent to the banks of the low water channel and sloping away from it. The soil of this alluvial valley is extremely fertile and has exceedingly high crop producing qualities.

The earliest white settlers, appreciating the fertility of the natural flood plain and desiring to plant, cultivate, and harvest crops in its extremely productive soil took measures to deny to the river some of that land to which natural laws entitle it for expansion during flood. They adopted the most simple, obvious, and practical means at hand to protect their farms and homes from the annual ravages of the river; earth levees. The early French grants of land contained a clause requiring the settler to build a levee along the river front of his property. The early valley dwellers soon had to join their levees with those of their neighbors and agree upon equal levee heights, for mutual protection. As the population and development of the valley increased, this co-operation extended successively through parishes, levee districts, states and finally, with the creation of the Mississippi River Commission in 1879, to the federal government. The levee method of flood control is not new, is not the invention of any engineer or group of engineers of recent times, but is as old as man. It was applied to the Mississippi by the early occupants of the delta country and grew with, and as a part of, the development of the valley.

In the course of this development the rightful domain of the river has been more and more encroached upon. Every new levee, reclaiming to man more, valuable land, has further confined and restricted the flood waters and required higher levee lines. There is a limit to this decrease in flood area and increase in levee height beyond which it is not only impractical and unwise, but hazardous and impossible, to go. This limit has been reached. The over-topping of levees, the occurrences of crevasses and evidences of sand boils behind the levees are the warning signals. In order to adequately protect the $5,000,000,000 of real and movable property of the farms, towns and cities in the natural flood plain of the Mississippi, and to preclude the possibility of the catastrophe which would result from a disastrous levee break, the disposal of the excess flood waters by overflow into limited natural auxiliary areas is obviously necessary. This is the underlying engineering principle of the "Adopted Project".

The engineering works and structures of this project limit the quantity of flood water carried in the main river channel to its safe capacity and permit the surplus water to spill through natural, lateral floodways into natural, back water areas and the Gulf of Mexico. The computations for the design of the levees and floodways are based on the estimated maximum flood height and quantity of water involved in the Mississippi River Commission's "Maximum Probable" and the Weather Bureau's "Maximum Possible", flood. These two bodies, conducting their observations and computations independently arrived at practically identical results. For the purpose of discussing the detailed engineering works of the project, the three principal sections into which the alluvial valley is divided by the Arkansas and Red Rivers and the back water areas at their junction

with the Mississippi, lend themselves to separate consideration as parts of the entire plan.

The northern section of the alluvial valley is that part from its nothern limit at Cape Girardeau, to the mouth of the Arkansas, including the St. Francis Basin on the west, and the back water area at the junction of the Arkansas, White, and Mississippi Rivers. From Cape Girardeau to Cairo, a distance of some 40 miles, a slight increase in the size of the levees will protect the low land on the west side of the river. Comparatively small areas of land on the east are subject to flood. At the confluence of the Ohio and Mississippi Rivers the protection of Cairo, Illinois, with a population of 15,000 souls, presents the first serious problem. Situated on a narrow point of land between the two rivers, some parts of the city are 20 feet below the top of the levees. It is unwise to further jeopardize these areas by increasing the levee heights here. Provision must be made to hold down the flood stage by allowing the water to be evacuated more efficiently. This is to be accomplished by a river bank floodway on the west side of the river below Cairo. The present river bank levee from Bird's Point opposite Cairo to St. John's Bayou, just east of New Madrid, about 70 miles long, will be retained, but the top will be lowered about three feet. A floodway will be created by the construction of a parallel levee set back some five miles. Normal high waters will continue to be contained within the present channel, but when the stage at Cairo becomes higher than five feet below the top of the levees there, the excess water will spill over the lowered river bank levee and enter the floodway. The automatic use by the river of this additional channel to the back water area of the St. John's Bayou will occur on an average of only once in ten years. Forty per cent of the area of this floodway is swamp and timber land which will be undamaged by flood water. From New Madrid to the mouth of the Arkansas the levees on the west side of the Mississippi will be slightly raised and strengthened to protect the St. Francis Basin. A relatively small area of land on the east side of the river from the Ohio to Memphis is subject to flood. From Memphis south, the levees on the east side will be strengthened to protect the Yazoo Basin. Local set backs will be made below Helena, Arkansas and at other bottle necks where it is considered necessary to provide greater cross section area to the main river channel. These works in conjunction with the natural back water areas at the mouths of the Arkansas, White, St. Francis Rivers and St. John's Bayou are expected to adequately protect the northern section of the valley.

The middle section of the alluvial valley, that part between the Arkansas and the Red Rivers, includes the Yazoo Basin on the east and the Tensas Basin on the west. In this portion the extreme floods can not be safely contained within the river bank levees of the Mississippi. To attempt to do so would require levee heights to be dangerously and unwisely increased. The "Adopted Project" provides for leaving the Boeuf Basin as a floodway, for excess flood water, to the back water area at the mouth of the Red River, in the lower Tensas Basin, before the flood stage in this section on the main river becomes hazardous. In addition to its advantages of location, shortness, width, and undeveloped state, the Boeuf Valley is the natural and therefore the logical path to be left in its existing status to supplement the capacity of this section of the Mississippi River. Suitable levees will be constructed in this valley to limit the area which nature has made a floodway. The head of the Boeuf floodway will retain its

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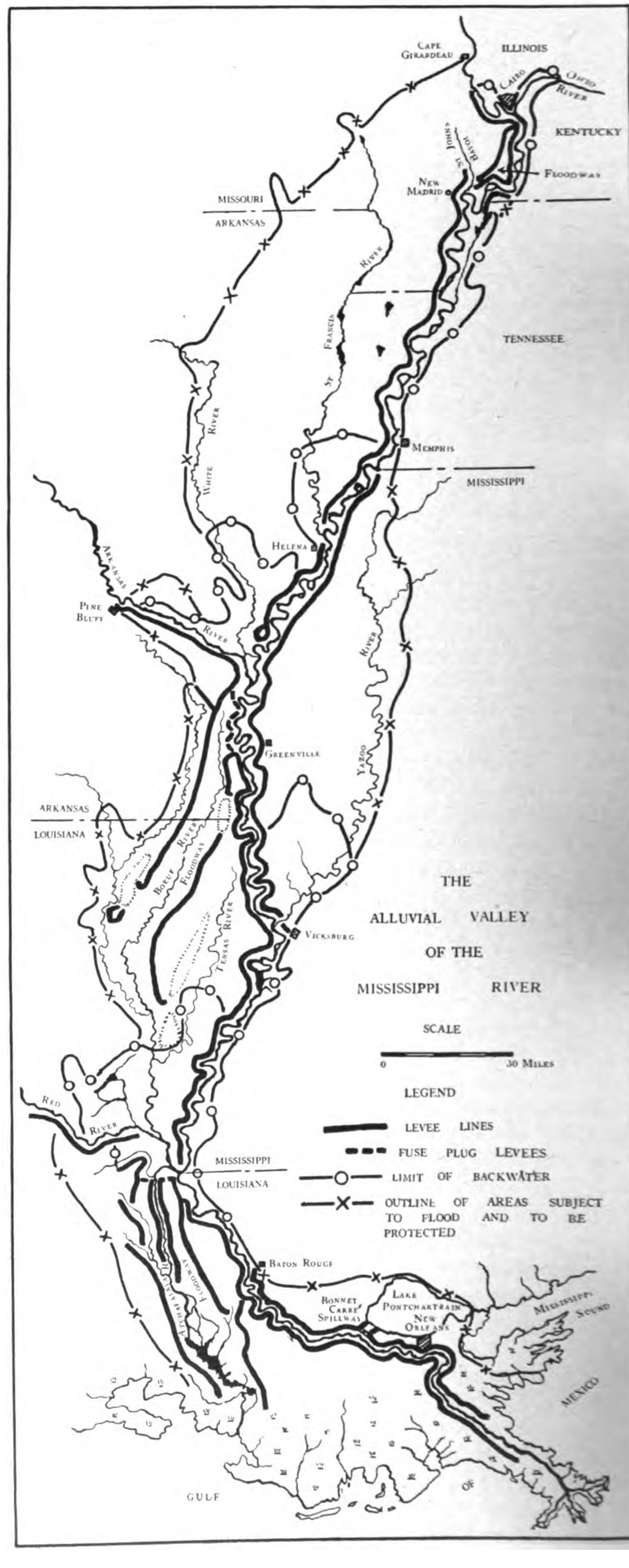
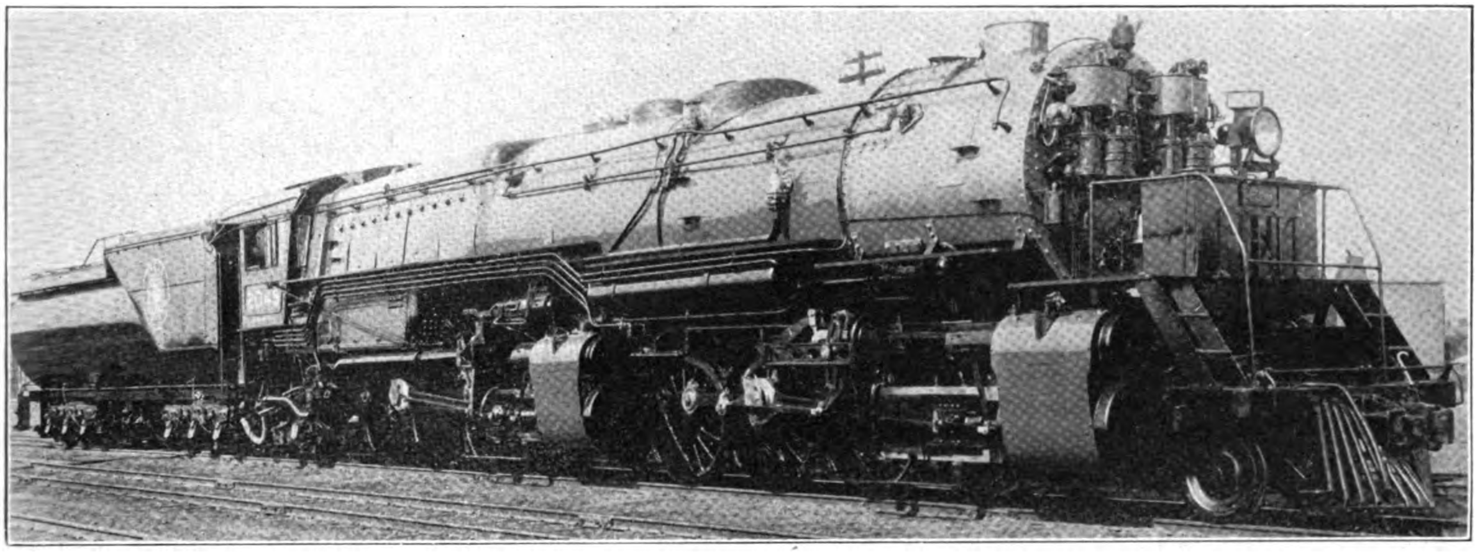
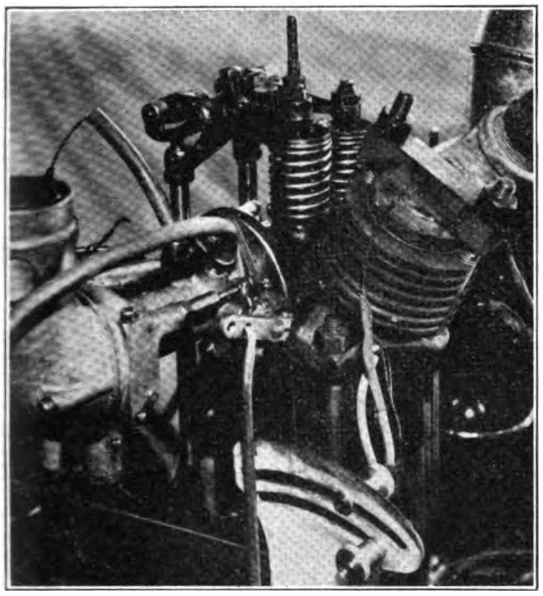




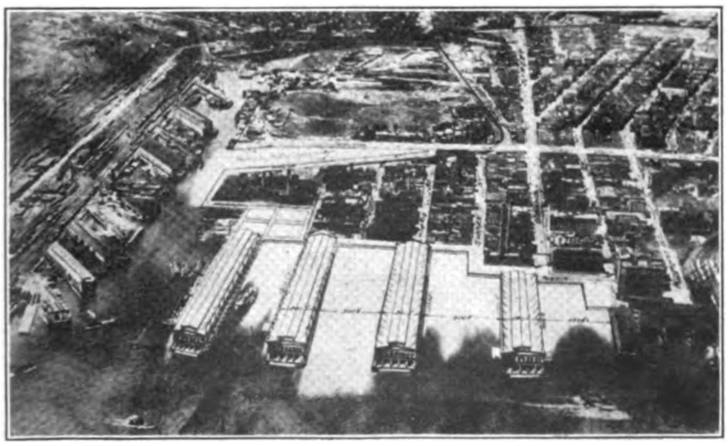


ABOVE.—*One of the Mallet type locomotives recently built and put into service by the Great Northern Railway. They are the most powerful simple Mallet engines ever built, having a maximum tractive effort of 153,000 lbs at 87% cutoff. The total weight of the engine and tender is 501 tons.*

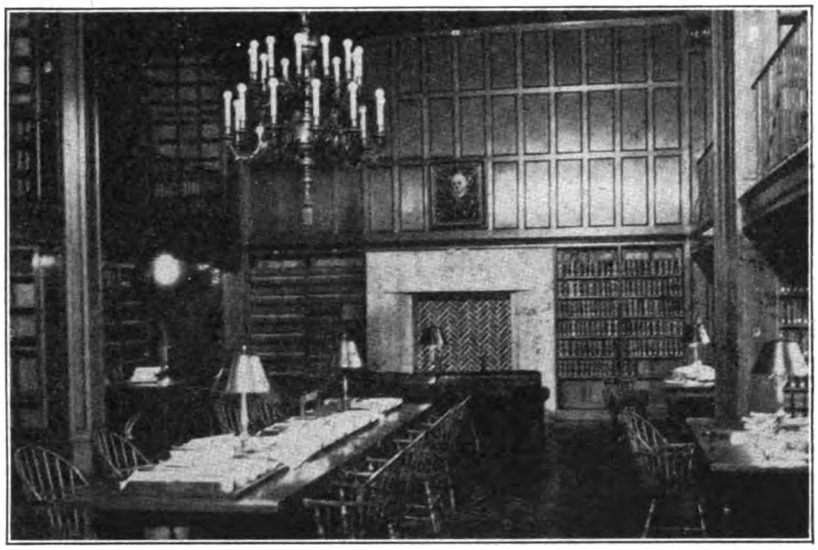
RIGHT.—*The Owyhee Irrigation dam, now under construction for the bureau of reclamation, is located thirty miles southwest of Nyssa, Oregon, on the Owyhee River. It will be of the massive concrete arch-gravity type, 405 feet high and 835 feet long at the crest. The reservoir, 52 miles long, will serve a watershed covering eleven thousand square miles. 540,000 cubic yards of concrete are to be used. The dam alone will cost about six million dollars, but the cost of the entire project is estimated at $18,-000,000. About 125,000 acres will be irrigated.*

ABOVE.—*Novel Internal Combustion Engine cylinder head being studied by Earl Pierce, a graduate student, at Mason Laboratory. This head is designed to induce, rather than suppress, detonation. Very interesting power curves are obtained from the design.*

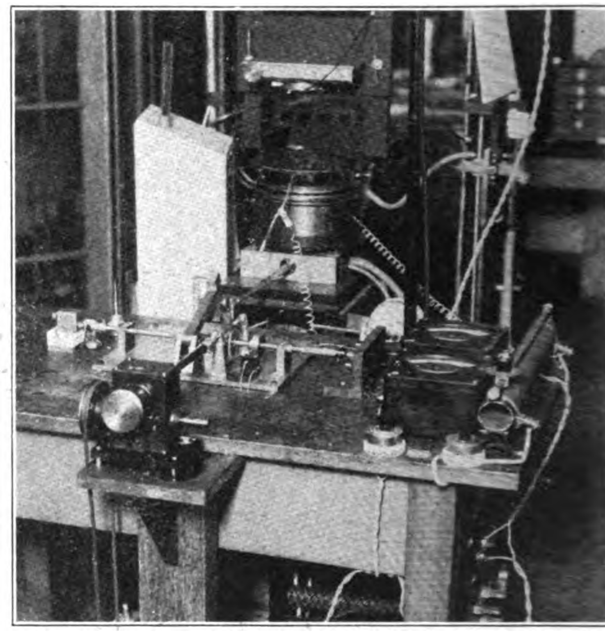
BELOW.—*The proposed Marine Terminal which the Port of New York Authority plans to build at the "Little Basin" in Jersey City. The project will include four modern steel piers, 1,000 to 1,200 feet in length, to accommodate the largest ships afloat; railway connections to all five trunk line railroads terminating in Jersey City; a marine basin for freight steamers and harbor craft; and a new highway similar to West Street in New York which will eventually extend to the Holland Tunnels. Ownership will revert to Jersey City when the development is paid for.*



ABOVE.—*The Fiftieth Anniversary Medal of the American Society of Mechanical Engineers symbolizes the characteristic forward-looking spirit of engineering and recalls past achievement. It commemorates a half century of the constructive influence of engineering on the social and economic elements of civilization and points to the unbounded possibilities of the future. By its award to distinguished engineers chosen by the engineering societies of sixteen countries its unifies throughout the world the ideal of the profession.*

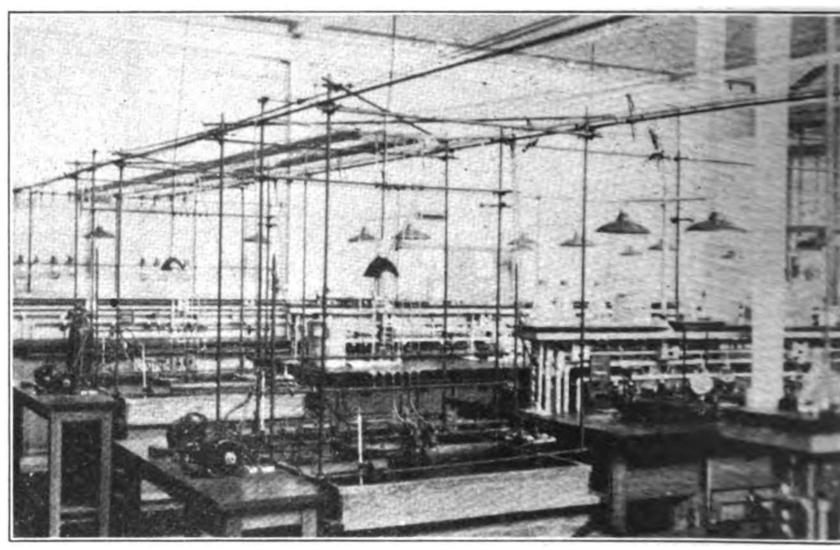


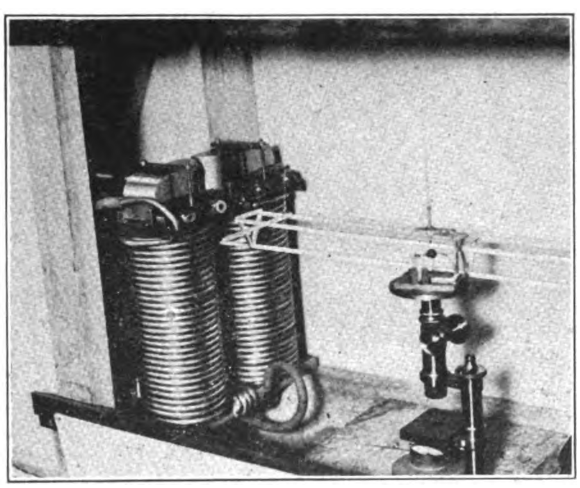
ABOVE.—*The library in the Sterling Chemistry Laboratory is one of the most attractive of its type in the country. Moreover it is excellently equipped with some seven thousand handbooks and periodicals. An oil painting of the donor of the building, John W. Sterling, (Yale, 1864) will be observed above the fireplace in the background.*



ABOVE.—*The Wilson Cloud Chamber which Mr. F. D. Kurie is using to determine the ranges of alpha particles. Such an instrument serves to make visible the tracks of ionizing particles and permits their being photographed. On the table in the foreground is a mechanism which operates the chamber automatically.*

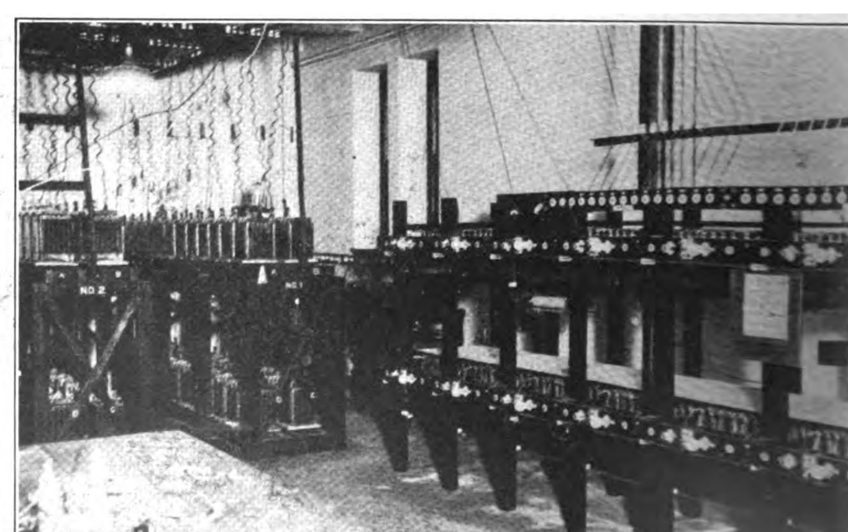
RIGHT.—*This picture of the newly-installed thermostats in the graduate physical chemistry laboratory is illustrative of some of the types of apparatus employed in the important work on the physical chemistry of solutions.*



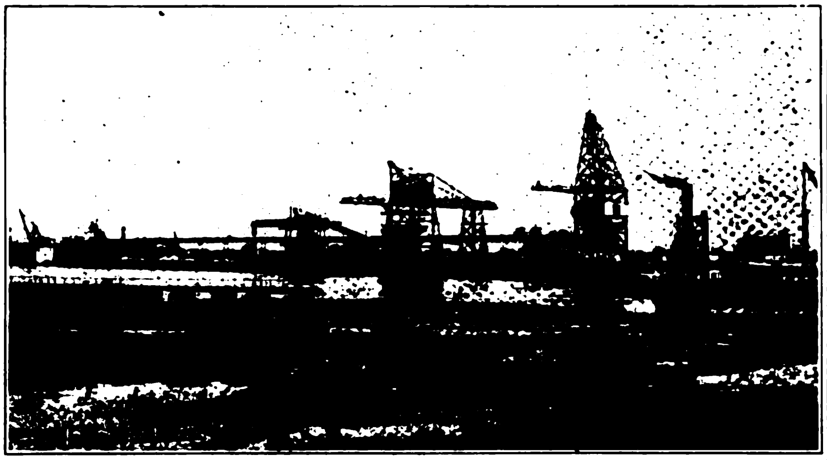


ABOVE.—*A portion of the apparatus for determining the magnetic susceptibility of crystals. It measures the extremely small force exerted on the crystal by the magnet. It was constructed by Mr. C. G. Montgomery who is using it at the present time to measure large single crystals of copper.*

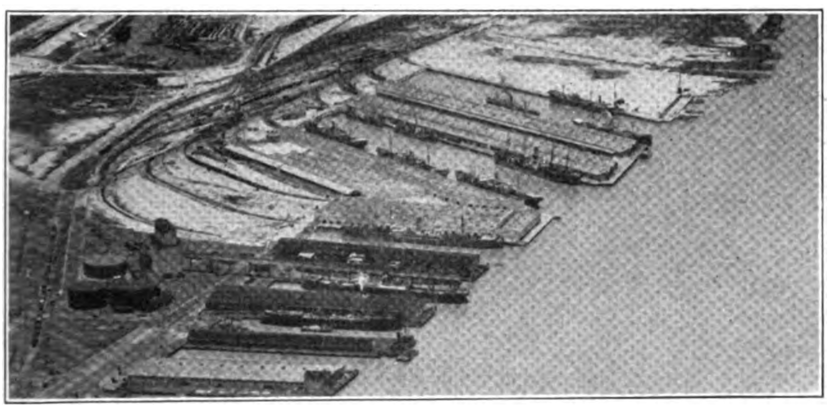
RIGHT.—*View of the Battery Room at Sloane Physics Laboratory, showing the high potential battery at the right, which is capable of giving a continuous current of 65 milliamperes at a potential of 4,000 volts. At the left is a heavy service battery for current at potentials up to 200 volts.*



Three views of the new Alabama Ocean Terminal at Mobile, Alabama which were completed two years ago at a cost of $10,000,000. The wharves are of concrete, with water alongside for vessels of thirty-foot draft. The covered floor space included within concrete-steel shipside sheds and warehouses totals almost twenty-five acres. Eighteen modern steamships can be docked at one time. Above is a photograph of the cotton docks and the loading for export. The building, of reinforced concrete and steel, is equipped with a high density compress with a capacity of 120 bales per hour.

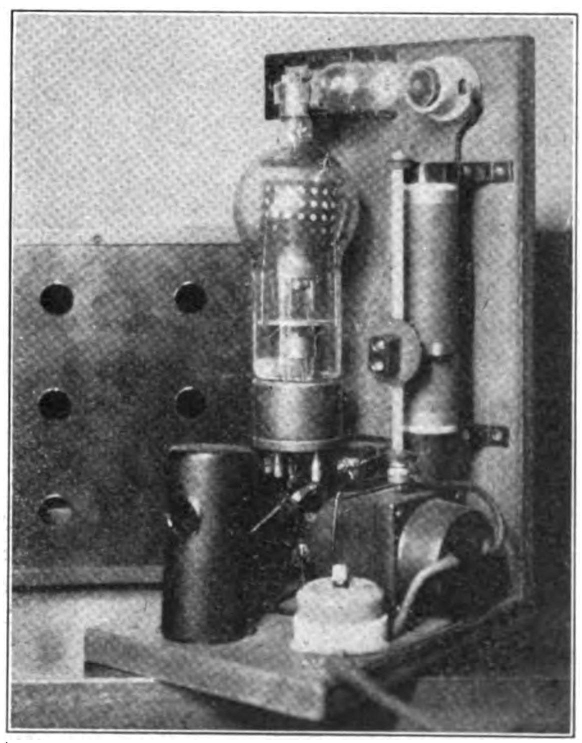


ABOVE.—*The unit for handling bunker and cargo coal. It has a capacity of 600 tons per hour and there is storage space for 35,000 tons.*

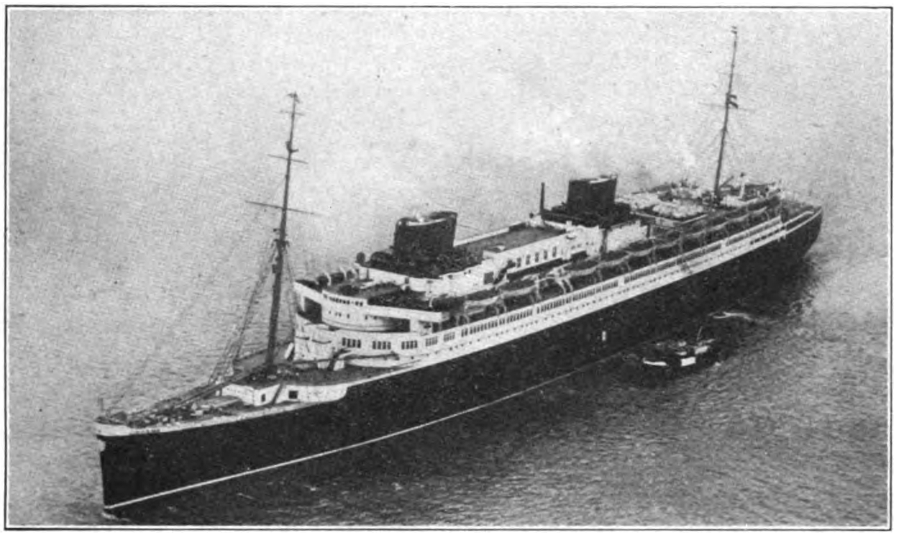


LEFT.—*An aerial view of the docks. The new piers shown in the center are typically 16,000 feet long, providing berths for three or four ships on a side of each pier. The slips are 350 feet wide and at an angle of fifty degrees downstream. Each wharf has three marginal tracks, with crossovers so located that cars may be switched to and from from one ship without interfering with operations at any other berth. Thus two tracks alongside of each berth are available for the cars for one ship. Cars are placed alongside under the ship's tackle for direct loading or unloading in one handling between car and the hold of the ship.*

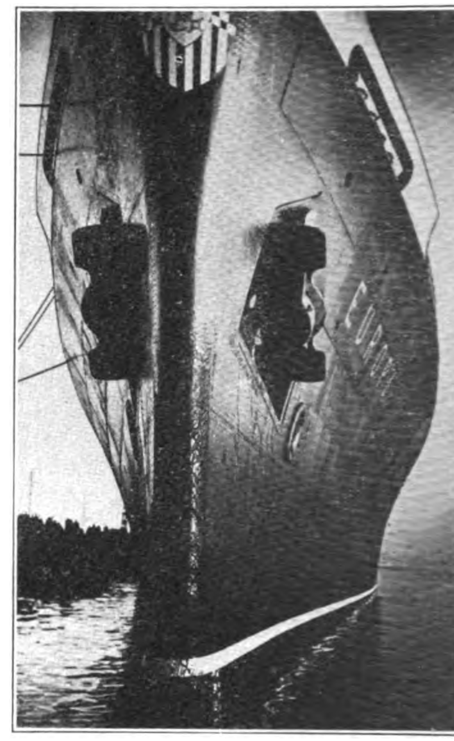
BELOW.—*A view of the Assaying Furnace in use at the Hammond Laboratory of Metallurgy.*



ABOVE.—*A Thyratron Control similar to the one recently demonstrated at the Electrical Engineering Exhibition. It is an electrostatically controlled mercury arc tube having varied uses as a power relay of large capacity and is capable of handling directly relatively heavy currents.*



ABOVE.—*The new North German Lloyd liner Europa, holder of the westbound crossing record, is 936 feet long and 101 feet broad. Note the elliptical shaped smokestacks. The boilers are located in two rooms, widely separated from one another, as indicated by the distance between the smokestacks.*

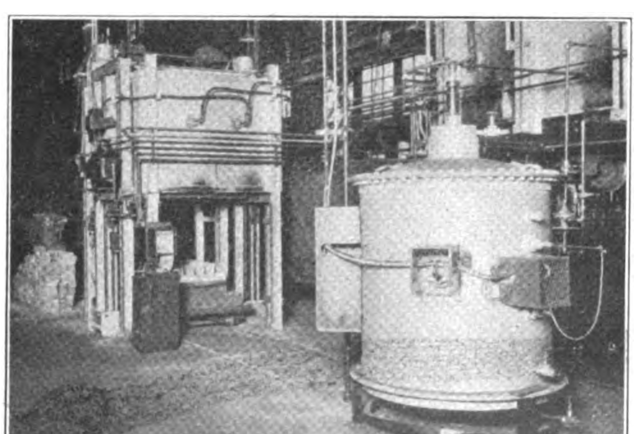


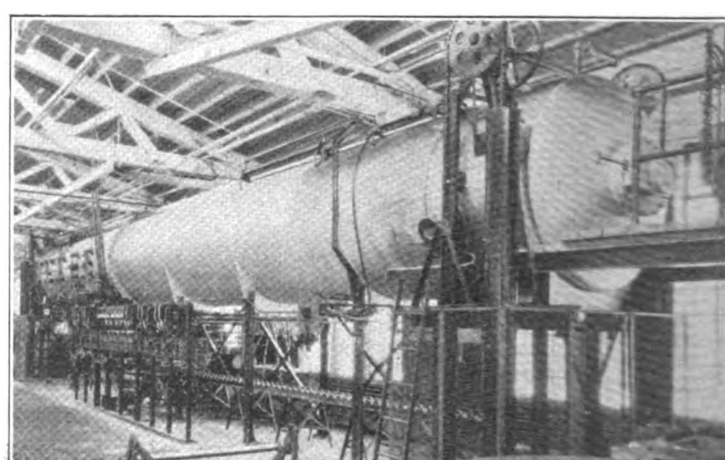
ABOVE.—*The Europa, like the Bremen, has the bulbous bow which creates "Dead Water" at the propellers, giving them a push which they could not get if the water were rushing by. Fourteen watertight bulkheads divide the ship into fifteen watertight compartments. In the event of the first four compartments of the ship being filled with water, she would still remain afloat without affecting the propulsive equipment.*

Underwood & Underwood.

LEFT.—*The Buzzard, a combination motor glider, developed by Orval Snyder and E. A. Johnson. It weighs only $467\frac{1}{2}$ pounds and carries a useful load of 340 pounds. By means of its two cylinder British A. B. C. pusher type motor mounted on the wing behind half the pilot it is able to attain a top speed of 85 miles per hour and average 40 miles per gallon of gasoline.*

BELOW.—*The gas electric annealing furnace on the left is supplied with gas of any desired properties by the apparatus on the right. This so called Electrolene Producer developed by General Electric will make almost any desired change in the physical and chemical properties of an industrial fuel gas by treatment with heat and steam.*





ABOVE.—*This furnace is designed to operate continuously to braze evaporator cases. The automatic discharging apparatus is visible in the foreground. On the left of this view may be seen the control panel and the leads to the heating chamber which is rated at 300 Kilowatts at 220 Volts-3 phase.*

P·E·R·S·O·N·A·L·I·T·I·E·S

SAMUEL W. DUDLEY.

RECIPE for making an Engineering Professor: Select an affable engineering graduate of Sigma Xi brand. Add a few years of graduate study diluted with elementary teaching in term time, and seasoned with industrial experience in the summer. Transplant from academic groves to industrial environment—experimental, testing, design, observation and study of operating conditions, contact with customers' engineers and managers. The subject is now prepared for professorial appointment; industrial and professional relations should be continued.

The excellence of the recipe is attested by its product, Professor S. W. Dudley. In particular: Born 1879; Hillhouse High School (New Haven) 1897; Yale, Ph.B. 1900, M.E. 1903; (Prize in Mechanical Engineering), taught shop visiting, machine design, descriptive geometry. Worked summers 1903-04 in pattern shop, foundry and test and entered regular employ, 1905, Westinghouse Air Brake Co. Became test engineer, special inspector, local engineer New York office supervising installation, instruction and maintenance work on new types of air brake equipment on electric locomotives and multiple unit cars New York Central and New Haven Railroad electrified zones. Returning to Pittsburgh he became Chief of Publicity department, preparing technical data, instructions, engineering and commercial literature. Assistant Mechanical Engineer; engineering analysis, project and negotiation correspondence, assistant at Lake Shore Railroad emergency brake tests; prepared reports. Assistant Chief Engineer with enlarged duties; representative at important tests on Pennsylvania and on Virginian Railroads. 1914, Chief Engineer, in charge of engineering, drawing room, testing and shop inspection. Author of a score of reports and papers relating principally to the Air Brake.

February, 1921, he came to Yale as Professor of Mechanical Engineering and since the retirement of Professor Breckenridge in 1923 has been Chairman of the department.

That Dudley is "a man you don't see or hear much of but afterwards find what he has done" is illustrated by the Machine Tool Exhibit. Professor Breckenridge did not believe in cluttering up his laboratory with appliances and machines that would soon be out of date. He cultivated temporary exhibits of the latest and best. He invited Brown and Sharpe one year, then Pratt and Whitney, then others to send their latest automatic lathe or other tool with a demonstrator. It was shown to students; then to prospective customers. The process was profitable as well as educational. Manufacturers were eager to come. The problem was turned over to Dudley. In a few years there was a Machine Tool Exhibit, sponsored by the Mechanical Engineering Department, the Chamber of Commerce and the American Society of Mechanical Engineers, filling Mason Laboratory with high quality machines of 150 manufacturers and attracting experts from the whole country. The Exhibit came during the Yale Mechanical Technology (Junior) course in September. An associate says, "It was Dudley's sound, good judgment and his quiet but effective leadership that made the first exhibition a success and paved the way for those that followed. It was of a different character from those usually entered into by the exhibiting companies. Many problems required tactful handling, and he displayed that characteristic fairness of mind and clearness of vision which has endeared him to all his friends."

His threefold familiarity with subject matter, with its use in practice and with the student mind qualify him as teacher. He is a member of the Scientific School, Freshman and Graduate faculties and of the governors of New Haven College, and is local Commissioner of the Boy Scouts of America. His diplomatic abilities are further demonstrated by his service as Chairman of the Music Committee of his Church.

A fellow student recalls his chief characteristics as "courtesy, studiousness and persistence."

An executive of the Air Brake Company says the period of Dudley's service "embraced the most important development and advances in the art of train braking since the active days in this field of Mr. George Westinghouse. Dudley possessed

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L·A·B·O·R·A·T·O·R·Y N·O·T·E·S

Civil Engineering

On March 28 the department entertained at luncheon Mr. Ralph Budd, President of the Great Northern Railway. Mr. Budd is a civil engineer by training and wide experience, and is the father of J. M. Budd of the Senior Class.

Professor Eckle recently attended an all-day joint session of the Connecticut Society of Civil Engineers and the Portland Cement Association, held in Hartford.

Mr. Lazarus White, of the firm of Spencer, White & Prentis, construction engineers, New York, gave a most practical and suggestive talk on Foundations to the Yale Student Chapter of the A. S. C. E. on March 27. Professor Krynine has been appointed a member of a special research committee of the American Society of Civil Engineers on Soils and Underground Construction. Mr. White is Chairman of the Committee.

Professor Krynine has begun an extensive program of research on soils in co-

(Continued on Page 28)

Industrial Engineering

Forty-eight Seniors from this department went on the annual Inspection Trip (March 25 to April 2) which, as usual, was planned and conducted by Professor Seward. The trip opened with a tour around the port of New York under the direction of officials of the Pennsylvania Railroad. This was followed by visits to plants in Philadelphia, Pittsburgh, Akron, Detroit, and Dayton. Among the companies not visited on previous inspection trips were: Aluminum Co. of America, Goodyear-Zeppelin Corporation, Packard Motor Car Company, and Frigidaire Corporation.

The Society for the Promotion of Engineering Education has asked Prof. Smith to conduct a session of the Summer School for Teachers on Preparing Engineers to Meet Problems of Managing and Dealing with Men.

Prof. Smith's book, "Psychology for Executives," has been published in Germany under the title, "Psychologie für Vorgesetzte."

Prof. Hastings has been appointed to the Budget Committee of the New Haven Community Chest.

Prof. Smith has been appointed a member of the Administrative Board of the Personnel Research Federation.

Chemical Engineering

Dr. E. R. Weidlein, director of the Mellon Institute for Industrial Research, spoke on March 20 to the Yale Student Chapter of the American Institute of Chemical Engineers on the opportunities for the future in chemical engineering.

The March issue of *Chemical and Metallurgical Engineering* contained an article by Mr. Raymond L. Copson and Prof. Harry A. Curtis on the development of a new process for the economical disposal of waste "kier liquors" from textile plants by the use of calcium chloride and flue gas. The same issue also contained an article by Mr. T. C. Lloyd on the work he has done to determine a new criterion for the coking value of coal.

Prof. Harry A. Curtis will be on sabbatical leave for the year 1930-31 and will take a position as chairman of the Division of Chemistry and Chemical Technology in the National Research Council at Washington. He will return on alternate week-ends to continue his conferences with research students in the department.

Mr. E. F. von Wettberg and Mr. N. S. Davis, who are to receive the Ph.D. degree in chemical engineering in June, have accepted positions with the Roessler and Hasslacher chemical concern. Mr. R. L. Kelner, also to receive his degree in June, will take up a position with the Henry L. Doherty Co. of Philadelphia.

Physics

A modern electrical distributing switchboard is being installed in the laboratory.

Professors L. Page and N. I. Adams are writing an advanced text book on Electricity and Magnetism.

Professor J. Stuart Foster of McGill University is coming to the laboratory on May first on a Sterling Fellowship to do research on the Stark effect in high fields. Professor Foster is a foremost authority on the effect that electric fields have of separating spectral lines into a number of components.

Professor R. B. Lindsay, who has accepted an Associate Professorship of Theoretical Physics at Brown University, has completed, in collaboration with Professor Stewart of Iowa, an advanced text on Acoustics, and has begun work on a text book of Mechanics.

(Continued on Page 28)

Mechanical Engineering

The death of Professor E. H. Lockwood of the Mechanical Engineering Department occurred April 14 after a sudden heart attack. He had been ill since the Christmas holidays, but had been thought to have been well on the road to recovery.

Born in 1866, he entered the Class of 1888 S. after preparing at the New Canaan Seminary. He was joint winner of the Junior Mathematics prize and received other honors for his excellence in his studies.

After graduating, he became a draftsman for the Diamond Match Co. in New Haven but returned to Yale as a graduate student and assistant in drawing. In 1890 he became an Instructor in Drawing and Mechanisms. From 1901 to 1924 he was Assistant Professor of Mechanical Engineering. In 1924 he was appointed Associate Professor. Since 1927 he had been Robert Higgin Professor of Mechanical Engineering and a mem-

(Continued on Page 28)

Medicine

At a meeting of the Yale Medical Society on December 11, 1929, the following papers were presented:

Some Factors Influencing the Character and Distribution of Adipose Tissue in the Rat by Lucille L. Reed, M.A., and William E. Anderson, M.A.

The Correlation Between the Weight of the Fetus and the Weight of the Placenta in Full-Term and in Premature Delivery by Sophie B. De Aberle, Ph.D., Arthur H. Morse, M.D., William R. Thompson, B.A., and Elizabeth H. Pitney, B.A.

The Independency of the Heat Polypnea Center by Allen D. Keller, Ph.D.

The Effect of Diet on Wound Healing by Samuel C. Harvey, M.D., and Edward I. Howes, M.D.

The New Haven Medical Society on December 4, 1929, was addressed on "Rheumatic Fever" by Dr. Warfield T. Longcope, Professor of Medicine at Johns Hopkins Medical School.

On December 18, 1929, Dr. Allen O. Whipple, Professor of Surgery at the College of Physicians and Surgeons, Columbia University, delivered a paper before the New Haven Medical Society on the subject of "Atypical Parenchymatous Cysts".

Geology

Prof. C. R. Longwell plans during the summer to make a field study of the Triassic rocks in central Connecticut.

Prof. Adolph Knopf and Mrs. Knopf expect to be in California through the summer, where they will take a vacation in the mountains and later make a study of the metamorphic rocks of the Coast Range.

Prof. Alan M. Bateman attended the annual meeting of the Society of Economic Geologists in Charlottsville, Va., April 24-26, where he gave a paper on the Geology of the Ores of the Rhodesian Copper Deposits. He expects to take a field trip to Alaska and will return to New Haven the first of August and spend the rest of the vacation there.

Prof. Richard Foster Flint has been appointed associate geologist on the Illinois State Geological Survey to make a study, during the coming summer, of the stratified sands and gravels deposited in connection with the Illinoian Glacial Ice Sheet in northwestern Illinois. Dr. Flint has also been appointed Associate Editor of the *American Journal of Science.*

(Continued on Page 28)

Psychology

Raymond Dodge, Professor of Psychology, Institute of Human Relations, left for Europe early in April to study the work and methods of the various European laboratories in the investigation of the Psychophysical reactions of subjects under psychiatrical observation.

Professor E. S. Robinson has undertaken interesting work in connection with the Buffalo Museum of Science to determine the psychological factors involved in securing from the point of view of the public the best methods of display of museum exhibits.

Robert M. Yerkes, Professor of Psychobiology, Institute of Human Relations, is spending the second term near Orange Park, Florida, in planning and constructing a laboratory station for the breeding and study of the behavior of anthropoid apes. The establishment of this station was made possible by a gift to Yale University from the Rockefeller Foundation.

Professor Roswell P. Angier will attend, as a member, the annual meeting of the Division of Anthropology and Psychology of the American Association for the Advancement of Science to be held in Washington on April 25th.

Biology

With the arrival of Spring, a large proportion of the laboratory staff is busily engaged in experimentation involving the use of amphibian embryos. The foreign visitors are all engaged in this type of work as well as a large proportion of the staff and students.

Dr. Karl Henke of the University of Göttingen has recently arrived and will spend the entire spring in the Osborn Laboratories working with Professor Harrison on problems in experimental embryology.

The meetings of the American Association of Anatomists were held April 17, 18, and 19 at Charlottesville, Virginia. They were attended by Drs. Nicholas and Twitty, as well as Prof. Stone from the Medical School. Papers were presented at these meetings by Mr. Yntema, Mr. Violette, and Dr. Nicholas. A large group of the former students of the laboratory were present at these meetings.

Professor L. L. Woodruff has just completed a revision of his textbook, "The Foundations of Biology," which has proved to be the most universally used text for beginning students in Biology in this country. Professor Baitsell is busy with a revision of the "Manual of Biological Forms" which is the accompanying text used in coördination with Professor Woodruff's "Foundations."

It is with extreme regret that the department makes public the resignation of Professor J. William Buchanan. Professor Buchanan's resignation will take effect at the end of the current academic year at which time he will take up his duties as Associate Professor of Biology at North Western University. The nine years which he has spent at Yale have been marked by faithful service, able teaching, and sound research. In his new field of endeavor he has the heartiest well wishes of his colleagues and students and their sincere congratulations on his advancement and the opportunities which the new position affords.

Mining and Metallurgy

The Department of Mining and Metallurgy is now installing a Hevi Duty Electric furnace, Type 55, 230 V., D.C.

The annual mine inspection and surveying trip this fall will begin the day after Labor Day at Sudbury, Ontario. The trip will as usual include visits to nickel, copper, zinc, gold, silver, and iron mines and treatment plants in Ontario, Quebec and New York.

Forestry

Plans have been made for the construction of an addition to Sage Hall during the coming summer. This new wing, which will extend east from the north end of the present building, is to be erected from funds derived from the bequest of Edward A. Bowers, who died in 1921. It will contain an auditorium in memory of Mr. Bowers, who was one of the early pioneers in the forestry movement.

Dean Graves is chairman of the Charles Lathrop Pack Forest Education Board, which has charge of the administration of the Pack Fellowships in Forestry. The purpose of these fellowships is to encourage men who have shown unusual intellectual and personal qualities to obtain training that will best equip them for future leadership in the various fields with which forestry is concerned.

"The Eli Whitney Forest" is the title of a bulletin, written by Prof. R. C. Hawley and William Maughan, Instructor in Applied Forestry, which has recently been published by the School of Forestry. This excellent bulletin, which is profusely illustrated, is of particular local interest

(Continued on Page 28)

Electrical Engineering

Professor A. E. Knowlton, now on leave of absence and serving as Associate Editor of the *Electrical World,* has presented his resignation to take effect June 30th, and will continue his editorial work.

Within the last decade three other Electrical Professors have joined the staff of the *Electrical World.* Professor H. V. Bozell, now associated with Bonbright & Company, L. W. W. Morrow, now editor of the *Electrical World,* and G. F. Wittig, Statistical Editor.

Professors Scott and Hall accompanied the Senior Electrical students on the inspection trip which included New York, Pittsburgh, Niagara and Schenectady. Among the companies visited were the Bell Telephone interests in New York, and the Westinghouse and General Electric Companies which are the three outstanding companies both in size and in the number of electrical graduates employed.

Niagara is the largest electric power production in the world and has the largest hydraulic units. The Lighting Institute in New York, the Chrysler Building, with several substations at different levels and the Research Laboratory and

(Continued on Page 28)

PHYSICS

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The following papers by members of the staff are to be given at the April meeting of the American Physical Society in Washington: "Disintegration Constant of Actino-Uranium and the Ratio of Actinium to Uranium" by A. F. Kovarik. "The Mobilities of Ions in Moist and Dry Air" by John Zeleny. "The Zeeman Effect in the Calcium Hydride Bands" by W. W. Watson and W. Bender.

The March 1 number of the *Physical Review* contains a paper by C. D. Cooksey and D. Cooksey on "The Glancing Angle of Reflection from Calcite for Silver X-rays." The April 1 number of the same journal contains a theoretical paper by J. Zeleny on "The Potential Relations in the Striated Positive Column of Electrical Discharges through Hydrogen." The next number of the Journal of the Franklin Institute is to contain an experimental paper by the same author on "The Fall of Potential between Striae in Electrical Discharges through Rarefied Hydrogen." He has in press also two short pages in *Nature* on "The Ions produced by Discharges at Liquid Surfaces" and on "A Singular Behavior of Striae in the Positive Column of an Electrical Discharge through Hydrogen."

FORESTRY

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because it describes the management of the forest lands of the New Haven Water Co., which have been under sustained yield management for a longer period than any other forest tract in America.

The annual Junior field work will be held this year from May 22 to June 11, under the direction of Professor Hawley and Mr. Maughan. Approximately eleven students are expected to assist in making a silvicultural plan of management of a portion of the Eli Whitney Forest in Northford. The area selected this year is in the vicinity of the new pipe line which has been laid from the Northford intake to the Gallaird Reservoir.

Professor Record has been chosen a member of the Standing Committee on Forest Resources appointed at the Fourth Pacific Science Congress convened in Java last summer. The function of the committee is to collect information as to the forest resources of the countries around and in the Pacific, particularly as regards present and future supplies of timber.

GEOLOGY

(Continued from Page 27)

Mr. W. O. Hickock, 4th, who was a graduate student in the Department of Geology last year has just returned from a year's study at the University of Freigburg, Germany, to continue his work as a candidate for the Doctor of Philosophy degree in Geology.

Twelve of the graduate students, under the guidance of Prof. C. O. Dunbar, spent the Spring vacation studying a section across the Appalachian Mountains in Pennsylvania.

Mr. A. C. Waters, instructor, who will take his PhD. degree in June, has accepted a position as instructor in the Geology Department of Leland Stanford University.

Mr. M. N. Bramlette has accepted the position of Geologist in a party of scientists who will make an extended expedition into Central Asia. Mr. Bramlette expects to be absent on this expedition more than two years.

CIVIL ENGINEERING

(Continued from Page 26)

operation with the State Highway Department. He has established testing apparatus at the Hammond Laboratory and will shortly have a piece of experimental highway built at Branford on which to verify his conclusions. He is conducting seminars in Soil Mechanics for graduate students and teachers.

On March 13, Mr. F. H. Frankland, director of engineering service of the American Institute of Steel Construction, delivered a short talk before the members of the Senior Class in Building Construction on the "Battledeck" type of floor construction. This is a new system for design and has interesting possibilities for use in certain types of buildings.

Professor and Mrs. Tracy entertained the Senior and Junior Civil Engineering classes and the Departmental Faculty at their Winthrop Avenue home on the evening of March 3rd. Mr. Tracy reminisced informally on "Fifty Years of Yale Athletics."

Professor Kirby recently attended the annual dinner meeting in New York of the Newcomen Society, an international organization for the study of the history of engineering and technology, of which he is a member.

Professor Suttie attended the two-day session of the New England Sewage Works Association at Boston in April. He is treasurer and a member of the executive committee.

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ELECTRICAL ENGINEERING

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Generating Station of the Brooklyn Edison Company are other unique and outstanding features included in the trip.

Recent lectures and technical meetings in the Dunham Laboratory include the following:

General R. I. Rees, Assistant Vice-President, American Telephone & Telegraph Co.,—"Engineers in Industry."

Dr. E. B. Roberts, Westinghouse Electric & Mfg. Co.—"The Cooperative Graduate Course of the University of Pittsburgh and the Westinghouse Company."

Mr. M. M. Boring, "Graduate Training in the General Electric Company."

These three speakers all laid emphasis upon the means afforded for continuation study by engineering graduates in the electrical industries, and pointed to the increasing demand for more high quality men with engineering training.

Percy H. Thomas, Consulting Engineer in New York—"Power Transmission."

Mr. E. B. Merriam, of the General Electric Company, spoke on "The Development of High Voltage Circuit Breakers."

F. H. Eastman and A. K. Wing spoke on "The Development of Magnetic Circuits in Electrical Machinery," and

S. E. Petrillo—"The Condenser Excited Induction Generator."

R. B. Whittredge—"Single Phase Loads from Polyphase Circuits."

Two of the student papers will be presented at the Regional Convention of the Institute to be held at Springfield, Mass.

MECHANICAL ENGINEERING

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ber of the governing board of the Scientific School.

He had received his M.E. degree in 1892 and a Ph.D. in 1901.

Articles by Professor Lockwood have appeared in numerous magazines, and he was joint author of several text books. In 1924 he invented a seismographic recorder for automobiles.

Among the numerous societies to which he belonged are: A. S. M. E.; American Association for the Advancement of Science; Society of Automotive Engineers; Yale Engineering Association; charter membership in the Yale chapter of Sigma XI; graduate membership in Tau Beta Pi in 1925.

Yale Engineering Association News

YALE ENGINEERING ASSOCIATION

C. J. LaRoche, '18 S., *Editor.*

G. S. Moore, '27 S., *Assistant Editor.*

Rex Daniels, '20S., *Assistant Editor.*

Officers of the Association.

Calvert Townley, 86 S., '86 Ph.B., '88 M.E., President.
Wyllys E. Dowd, Jr., '00 S., First Vice-President.
Samuel Insull, Jr., '21 S., Second Vice-President.
Billings Wilson, '16 S., Secretary-Treasurer.

Executive Committee

F. C. Pratt, '88 S.	C. J. LaRoche, '18 S.	R. C. Morse, '06 S.
B. Stoughton, '93 S.	A. W. Dater, '95 S.	A. S. Blagden, '01 S.
H. T. Herr, '99 S.	J. W. Marshall, '07 S.	S. W. Dudley, '00 S.
Oliver S. Lyford, '90 S.	A. H. Rudd, '86 S.	E. E. Minor, '96 S.
S. F. Ferguson, '94 S.	E. M. T. Ryder, '98 S.	R. C. Lanphier, '97 S.
E. M. T. Ryder, '96 S.	R. H. Matthiessen, '12 S.	

Address all communications to this department to C. J. LaRoche, Yale Club, New York, N. Y.

REPORT OF EXECUTIVE COMMITTEE OF YALE ENGINEERING ASSOCIATION

By Calvert Townley, *President*

YOUR constitution provides that your Executive Committee shall present an Annual Report, in accordance with which requirement and on behalf of that Committee, it is my duty and privilege to submit the following summary of the Committee's activities during the administration year.

Following the experience of previous years, it has been unnecessary for your Committee to have frequent formal meetings. Instead frequent informal conferences between small groups of its members and numerous discussions with the President, with other administrative officers of the University and with members of the faculty have taken place.

One formal meeting was held at the Yale Club, New York, on January 7th, at which the activities of the various sub-committees and of individual members were reviewed and plans for future work discussed. Present at this meeting were Messrs. Dowd, Ferguson, Lyford, Dudley, Minor, Ryder, Rudd and Townley. Mr. Cornell acted for Secretary Wilson and Mr. Lowrie, Landscape Architect for the Yale Bowl, was present part of the time by invitation.

The general activity of your Committee members may be briefly summarized as follows: A sub-committee on landscape engineering comprising S. F. Ferguson, E. E. Minor and Ralph D. Matthiessen, has been active in preparing a comprehensive plan for beautifying the surroundings of the Yale Bowl. As you know, the University owns a large tract of land, already largely used and intended for complete ultimate use for athletic purposes, on a part of which is the Yale Bowl. The Walter Camp memorial gateway decorates one entrance to this tract and the Athletic Club house and the Armory are located there. Your Association conceived the idea that it should be possible to so develop this tract by proper landscaping as to make it exceedingly beautiful, without interfering in any way with its utilitarian purposes, and that the Association could be of service to the University and could demonstrate its interest in University affairs by undertaking the task of preparing plans for such landscaping.

The subject was discussed with Mr. Woodcock, Manager of the Yale Athletic Association, and with other interested officials, all of whom cordially welcomed your Association's offer and expressed a willingness to cooperate. The first move was to secure a competent landscape architect, and your sub-committee was gratified to find in the person of Charles N. Lowrie '91S one of the outstanding landscape architects of the country. Mr. Lowrie was accordingly retained. He has devoted a great deal of time to a study of the property and has prepared complete landscape plans for its ultimate development. Throughout his work, both he and the members of your sub-committee have been in frequent consultation with officers of the Yale Athletic Association who have cooperated cordially and enthusiastically, it being the Committee's aim to have all plans receive the full sanction and approval of those officials.

The Committee had hoped to present these plans here tonight, for your inspection, but as they are not yet quite in final shape, out of courtesy to the University officials concerned, it has been felt that they should not yet be released. I am permitted to say however that a part of Mr. Lowrie's plan is a provision for comfort stations for the Bowl, ample in number, sufficiently commodious and having an attractive, but not obtrusive, exterior architecture.

The preparation of these plans calls for a total ultimate expenditure of $2,000 by your Association, provision for which has been made by an allocation of funds already in hand.

Informal conferences have been held with Dean Warren, at his invitation, with respect to the housing or quadrangle plan. Now that the University is assured of funds needed to build a sufficient number of dormitories to house the undergraduate body, a question of whether Sheff students will participate in these new facilities becomes one of absorbing interest. The University authorities give evidence of being cordially open minded, and it will soon be necessary for the Sheffield Trustees, faculty and graduates to decide whether or not they desire to have Sheffield maintain and perhaps increase its independent position or become more closely a part of the University as a whole. Acquisition of the remaining parcels of land accomplishing complete Sheffield ownership of Sheffield campus square, bounded by College, Grove, Temple and Wall Streets, assures more than a possibility that Sheffield will have additional dormitories on this campus sufficient to house her student body. If Sheffield students are to be allowed to room in the University's quadrangles, it would seem almost to go without saying that reciprocal privileges with respect to the Sheffield dormitories should be offered to the college students.

This is only one angle of the many sided problem that must now be solved and into the discussion of which your officers have been invited. It is thought that your Association may be helpful both in disseminating among graduates information as to the New Haven problem and by informing University authorities with respect to the concensus of graduates opinion in so far as they may be able to ascertain it.

Plans for a new building to replace old South Sheffield at the head of College Street have been completed and substantially

approved. Some minor changes are still contemplated so that the plans have not yet been released for public inspection. Some of your officers have been privileged to examine these plans and are enthusiastic in their admiration of the masterly way in which the architect, Mr. Clarence C. Zantzinger '92S has risen to the occasion and prepared a very splendid design of the building which is to stand on perhaps the finest site the University owns and be a most outstanding credit to the Sheffield Scientific School.

While the desirability of replacing Old South Sheff with a modern structure might be said to have been obvious for a long time, in this instance—as in many others—the obvious continued to be obvious but nobody was doing anything about it until the idea was crystallized at a meeting of the Executive Committee of Yale Engineering Association some time ago, as a result of which Past Presidents, O. S. Lyford and Smith F. Ferguson were active in initiating and following up discussions with the University authorities. Without in the least desiring to claim any undue credit, these facts should be recognized and your Association should take a proper amount of pride in the probable early consummation of plans for this outstanding improvement.

Changes in the courses of study, in the teaching staff and otherwise in the equipment of Sheffield have resulted in great improvement, but it is felt that the general public, the preparatory schools and even our own graduates are not sufficiently informed with regard thereto. Your Past President, Mr. O. S. Lyford, as Chairman of your Committee on University Affairs has been particularly active in discussing this situation with the University authorities and in developing plans for its remedy.

A number of conferences have been had between Mr. Lyford and Professor Crawford, head of the University Department for Personnel Study with a view of developing benefits to Sheffield, which might result from a better utilization of the Department of personnel study. There are no concrete plans that can be reported as the result of these conferences and it is hoped and believed that opportunity for very direct results may be found.

As you know, the former practice of preparing and distributing to the membership occasional news letters largely through the energetic efforts of your former secretary, Mr. Ryder, has been supplanted by the publication of the Yale Scientific Magazine, copies of which are furnished gratis to each member of the Association. Mr. Chester J. LaRoche, Chairman of your Publicity Committee, and Mr. George S. Moore have actively maintained supervisory contact with the undergraduate students who are publishing this magazine.

As time goes on, certain facts become increasingly apparent:

First: That the organization of your Association as a vehicle for consolidating graduate opinion and to secure united graduate support for Sheffield Scientific School was a wise procedure.

Second: That the Association has secured an enviable prestige and standing as an affiliated University body and has earned a large measure of confidence in the minds of the University authorities from the Corporation down. We have enjoyed an enviable measure of support from the graduates who have loyally backed the efforts of your officers. Our chief difficulty is in properly informing the general membership about what is going on and thereby demonstrating to the busy men who constitute that membership that there is a real mission for the Yale Engineering Association to perform and that by continuing their support, members are performing a real service to Yale and to the Sheffield Scientific School.

Alexander H. Rudd—'86S. Mr. Rudd's speech at the recent banquet of the Yale Engineering Association was one of the features of the meeting, and one of the surprises. His uproariously funny talk rivalled in its pointed witticisms the best humor of some of our leading after dinner speakers—like Benchley or Will Rogers.

The Secretary of the Port Authority, New York, Resigns His Job as Secretary of the Yale Engineering Association.

Billings Wilson, after several years of record service, has relinquished the job of secretary of the association. He will probably still serve on some important committees.

The recent election of W. R. Dowd, Jr. '00S. as Vice-President of the Yale Engineering Association was received with pleasure by his friends who have known of the hard work put in for many years during his service on many of the committees.

Moore A Banker

George S. Moore, the new secretary of the association is an assistant to the president of the Farmers Loan & Trust Company. He was the founder of the Yale Scientific Magazine, which, by the way, in its very first year earned a profit and is now established as a real factor in Yale undergraduate life.

The New Course

Everywhere among Yale graduates, there has been evidenced interest in the new Applied Economics Science course.

Every Yale graduate should be familiar with this course. This course reflects the fact that college graduates, those in charge of banking, investments or other business enterprizes, have in recent years been increasingly insistent on a thorough knowledge of economic principles.

The course, in the Sophomore year, covers the subjects of Elementary Economics, Social Evolution, and Modern Languages.

In the Junior year, it covers Principles of Accounting, Distributing Systems, Corporation Finance, Industrial Physiology, Business Law.

In the Senior year it covers Accounting and Finance, Transportation Commerce, Utilities, Statistics, Business Forecasting, Personnel problems.

It is felt that when information concerning this course is better known to the students of Prep Schools and High Schools throughout the country, it will prove to be very popular.

DIESEL ELECTRIC LOCOMOTIVES

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have been developing a 2-cycle engine for railway work. This engine, including the generator, is 7 feet 6 inches long, 4 feet 6 inches high and 4 feet 6 inches wide, these dimensions including the generator. By the use of special materials and for the purpose of reduction of weight for aviation, an "X" engine is being constructed, with a weight per horsepower of 3½ pounds and dimensions of 4 feet in length, 4 feet 6 inches in height and 4 feet 6 inches in width. None of these 2-cycle engines has as yet been applied commercially, but the development assures a Diesel engine-generator unit of high power, low weight and small space.

There are many advantages in this type of electric traction, which, as I have indicated, has only become possible through the development of the high-speed light-weight Diesel engine.

Few railroads have traffic and operating conditions to justify electrification such as has been in operation on the Pennsylvania, New York Central, New York, New Haven & Hartford, Virginian and Norfolk & Western Railroads. The reason for this is that the initial expense of electrification is large and the investment fixed, notwithstanding the effective operation that results. With Diesel-electric traction the motive power is mobile and each unit can be used anywhere. The Diesel engine has the great feature of being efficient in small sizes, that is, with small power output. Its efficiency at variable speed and power outputs is nearly constant. It lends itself admirably, therefore, to economical operation in railway traction, and when sufficient experience has been had in this service, with this type of prime mover, great economies should result in its use.

In Diesel-electric operation division points can be located at very much greater distances from each other than is the case in steam operation. The problems of water supply on the railroads disappear.

All the fuel used by the motive power of railroads has to be transported to the terminals from which it is dispensed. The Diesel engine, using fuel oil, will actually consume for a given output about one-fifth of the weight of fuel that a steam locomotive consumes using coal, and one has only to examine railroad statistics to see the enormous tonnage in fuel utilized for motive power purposes to form some idea of the savings in transportation and equipment available for this item. Again, fuel oil can be very much more cheaply and readily handled, bulk for bulk, than coal, and when only one-fifth is required, this cost is greatly diminished. Another of the great economies effected by the use of Diesel-electric traction is the saving in fuel over steam operation in standby losses at terminals and on the road at meeting and passing points, etc. The consumption of fuel under such conditions cannot be avoided by the steam engine, but can be entirely eliminated with the Diesel engine.

With a total consumption of 150,000,000 tons of coal per annum on our railways, it is easy to visualize what might be done in the way of saving fuel transportation if the motive power were furnished by Diesel engines.

Twenty-five million tons of oil would replace 150,000,000 tons of coal, and 500,000 carloads of oil would do the work of 3,000,000 carloads of coal per annum.

As to cost, the Canadian National Railways locomotive has handled passenger trains on regular schedule with less than one pound of oil per passenger car mile and 1,000 ton miles in freight on less than 20 pounds of oil.

With coal at $2.50 per ton on the locomotive and oil at 5c per gallon, the ratio of cost is approximately 5 to 1 in favor of coal pound for pound. However, the consumption is over 6 to 1 in favor of oil. The great savings, however, are in the less equipment required to handle a given tonnage and the elimination of engine terminals, water supply, etc.

CIVIL ENGINEERING

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In our last issue, mention was made of the summer school for civil engineering teachers which is to be held at Yale for three weeks in July, under the general auspices of the Society for the Promotion of Engineering Education, with Professor Tracy as local director. The project has met with enthusiastic country-wide support and the attendance promises to exceed expectations.

THE QUANTUM THEORY

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mathematicians, when values are assigned to the arbitrary constants. In particular, if the string is supposed fixed at two points, the frequencies of the permitted vibrations are strictly determined. And the string will be in the form of a sinusoidal, stationary oscillation.

The analogy of this type of problem to the usual one in atomic physics is complete. The imposition of the boundary-conditions on the solutions of Schrödinger's equation fixes stationary waves in space. The wave-lengths of the possible vibrations are determined uniquely in terms of the characteristic energy-values, and consequently, h. Thus the optical constant h, which was introduced almost apologetically at the beginning, has become the means of making the subject of mechanics a branch of optics. Only a century ago physicists were straining every possibility to achieve the opposite.

The actual difference between the quantum and the electron is best expressed in terms of the principle of restricted relativity. The quantum has a mass which is independent of the velocity of the observer; the electron, one which is directly proportional to the relative velocity of the observer. And as for the vibrations of light, these can be considered as material oscillations that have no dispersion—in other words, their phase-velocity is equal to their group velocity. Therefore the electron and the light-quantum are to be viewed as different aspects of the same physical phenomenon. This is continuous along a given direction in space and is characterized by certain singularities, i.e., nodes, which lend an appearance of discontinuity (compare a beaded string). Hence, the Schrödinger equation with its boundary-conditions is an expression of both the continuity desired by the classical theory and the discontinuity demanded by the quantum theory.

The preceding paragraph must not be taken too seriously. It breathes hope, rather than truth. There is much to be cleared away before any such Utopia is sighted by investigators. Some regard Schrödinger's equation as only incidental to a larger field of physical laws. Some look upon it as only an expedient. Moreover, there is another interpretation of it that is more accredited

than the one that has been presented here. It is purely statistical. For example, it claims that the equation determines not the actual energy, but the probable energy. One can not speak of a definite position and of a definite velocity of an electron, only of a probable place and of a probable direction. Furthermore, Heisenberg finds in his quantum condition the fact that the position and the momentum cannot be determined separately, only their product (the Indetermination Principle). However, all these views seem to be too pessimistic for Physics, which has been nurtured on optimism. Its progress in the past has been due mainly to an implicit faith in the resolvability of macrocosmic effects into microcosmic elements. Perhaps Physics must now reverse this order. But the Compton Effect does not indicate any such change as being necessary. Nor does the experimental finding of the diffraction of electrons, i.e., of the material waves, by Davisson and Guermer call for us to abandon our optimism —yet.

HISTORY OF THE BIRTHPLACE OF SHEFF

(Continued from Page 5)

building. The chemical work of the school was carried on there from 1860 until 1895, when a new chemical laboratory was erected. Among other notable pieces of chemical work was that of Dr. Samuel Johnson in Agricultural Chemistry, and it was largely through the importance of this work and his efforts that in 1877 the State Legislature established the Connecticut Agricultural Experiment Station, the first of its kind in America. The work of this Station was first carried on in two rooms on the first floor. Incidentally, as one who was himself a student of chemistry in this laboratory back in the early nineties, the writer sometimes wonders just how it would strike one of our Senior chemical students of today to be in some way transferred from the Sterling Chemistry Laboratory with its marvelous appointments back into that old laboratory, as he knew it, with its closely crowded wooden benches packed with reagent bottles, its very large lack of ventilation, but no lack of concentrated smells, its primitive sandbath, common to all, and heated by a coal fire somewhere in an interior known only to the immortal "Pfeifers", father and son, those faithful janitorial aids (?) to chemical experiment. Would our Senior, we wonder, feel that he could do any good work there? Would he think he was treated quite right, and would he perhaps discover as did his forebears that sand-baths could roast eggs as well as chemicals?

In a small room on the second floor, Russell H. Chittenden started the first Laboratory of Physiological Chemistry which was destined under his direction to become and to remain for many years the leading center for work of this kind.

Botany at Yale, under Professor D. Cady Eaton, got its start in this building, and Professor Eaton's notable collection was housed in a fireproof vault for many years.

So important a scientific center had this building become as early as 1869, that it was selected by Dr. Clarence King, the first Director of the United States Geological Survey, to be for a time the headquarters for the work of the Survey.

George J. Brush, appointed professor of Metallurgy, in 1855, early began assembling his noted collection of minerals and housed them in Sheffield Hall for many years. The early research work in mineralogy of Brush and Penfield which was to bring such distinction to Yale in this field was carried out in the old Sheffield laboratories.

All of the earlier work of the School in physics and engineering was in some way done in this building until in 1873 when part of it was transferred together with much of the classroom work in other subjects to North Sheffield Hall which was erected in that year by Mr. Sheffield.

In Sheffield Hall Daniel C. Gilman, later to be the first president of Johns Hopkins University, taught physical geography, General Francis A. Walker, the economist and later president of the Massachusetts Institute of Technology, taught political economy, William C. Whitney, the great philologist, gave instruction in German, and Thomas R. Lounsbury, the noted English scholar, began the first course of which there is any record of English treated as literature, and which may be truly said to have furnished the model and the inspiration for the best of our modern courses of English literature.

In a commodious room at the top of the north wing was a library, which, although an unknown mystery to most of the students, contained together with important scientific works the very valuable Hillhouse mathematical collection of books. In later years this old library room was used both as library and the headquarters for the graduate school of business administration which made a most promising start, enjoyed a brief period of successful existence, but came to an unfortunate and sudden end with the reorganization of the University in 1919-1920.

In 1902 some years after the work in Chemistry had moved to new quarters, a bacteriological laboratory was located in several of the rooms on the second floor and was the center for research and instruction in this field for twenty-five years or until more commodious quarters were provided in the new group of Medical School buildings. The rooms vacated by bacteriology are now the headquarters for the work in Industrial Engineering so that again after a lapse of many years engineering has in some part come back to its earlier home.

We must not forget either that Sheffield Hall afforded on the second floor front a room that was for many years occupied by Professor William H. Brewer, and there he did much of his work and kept many of his books, maps, and some part of his personal collections. This, to those who knew this most versatile of men, is equivalent to saying that a very great variety of scientific work was done there, and that nothing that was of vital interest to mankind was not given some attention in that room. No one who ever visited Mr. Brewer there is likely to have forgotten the experience. We recall, for example, a set of large sealed glass jars on a shelf high up under the ceiling, filled by Mr. Brewer with muddy water from the lower Mississippi River way back in the 1870's. They were still muddy after thirty years, all but one, and that was clear. He had put a very little salt into that one in order to prove for the first time that the presence of what we now call an electrolyte was the immediate cause of the rapid precipitation of the suspended sediment at the river mouth where the salt waters of the Gulf were encountered.

We might go on almost indefinitely with our account of the important educational activities which were carried on in this building and bear witness of the many men whose minds were stimulated by what they saw and heard and learned within its halls under the influence of the many notable men who carried on their work therein.

Though Sheffield Hall may to those of us who today view it amidst its modern and architecturally more beautiful surroundings appear homely and out of date, we must not forget that

to an earlier generation it was regarded with the great respect due to a structure which was playing a notable part in scientific education and scientific work. It was the home where many of Yale's most notable enterprises had their birth and where others were nourished through their earlier years and from which they have one by one departed by reason of their growth and greater requirements. When the new and beautiful structure designed by Mr. Zantzinger shall have replaced "Old Sheff", we can only hope that after three quarters of a century of use its historian will be able in turn to write as correspondingly a fine record of service as can be done today for its predecessor.

THE 1930 SENIOR INSPECTION TRIP

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The next two days were spent in Pittsburgh, where the electrical engineers joined forces with their mechanical and industrial brethren. The first visit in the Pittsburgh region was to the Homestead Works of the Carnegie Steel Company, and brought the Yale students into contact with the great industry for which Pittsburgh is famous. At the Homestead Works molten iron is brought two miles in ladle cars from seven blast furnaces on the other side of the Monongahela River, and charged with steel scrap into sixty-five open hearth furnaces. The visitors watched the tapping of one 100-ton furnace into a huge ladle suspended from an overhead crane, and the pouring of the molten steel into ingot molds. The path of the ingots which cooled in the molds was traced past the stripper where the molds are removed, the soaking pits for reheating, to the blommers, the roughing and finishing mills, until finally structural shapes emerged on the hot beds. The giant D. C. electric motors which drive the reversing mills were inspected, and their control by an operator in an enclosure some distance from the mill watched.

Leaving the Homestead Works, a stop was made at the South Duquesne Carnegie blast furnace plant at the time a cast was being made from one of the furnaces.

In the afternoon of the first day in Pittsburgh the group went out to New Kensington, lunch being served on the way by the Pennsylvania Railroad. At New Kensington the party was taken through the plant of the Aluminum Company of America.

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MISSISSIPPI FLOOD CONTROL PLAN

(Continued from Page 20)

existing levees along the west bank of the Mississippi at Cypress Creek, near the mouth of the Arkansas, to function as a fuse-plug levee. This levee will be the height of the present levees in this section while the rest of the main river levees will be raised three feet. Consequently, before the Mississippi reaches the danger stage, the excess water will overflow the fuse-plug section and enter the floodway. The floodway is thus seen to be automatic; the river will top the Cypress Creek levee when it reaches the stage at which it demands greater outlet capacity than it has in the main channel. The necessity for the Boeuf floodway will occur on an average of once in 12 years. The floodway is 60 per cent swamp and timber land which will be undamaged by flood waters. The slight increase in the height of the levees on the Arkansas and Mississippi and the functioning of the Boeuf floodway in conjunction with the back water storage area at the mouth of the Red will adequately protect the middle section of the alluvial valley, including the Tensas and Yazoo Basins.

The southern section of the alluvial valley is that part from the Red River to the Gulf of Mexico. Under the "Adopted Project", setbacks of the main river bank levees will be made at critical places in this section to secure a better discharge of flood waters, but these measures will not increase materially the carrying capacity of the leveed channel of the Mississippi. The hazard involved in increasing levee heights sufficiently to provide the necessary capacity to accommodate the maximum flood, in this channel, is so great as to render that method impracticable. In addition to the unsafeness of the increased levee heights at New Orleans, the cost of raising these levees and of reconstructing the wharves built upon them is unwarranted. New Orleans with its half million people and property value of over a billion dollars must be protected and its port facilities unimpaired. The value of its annual tonnage is over $900,000,000. Its foreign tonnage is surpassed in value by only one other port of the United States. The "Adopted Project" will provide protection for New Orleans by diverting excess waters through a special leveed floodway into Lake Pontchartrain at Bonnet Carré 20 miles above the city. By means of a movable dam and a concrete spillway at Bonnet Carré the quantity of flood water entering into this floodway will be restricted and limited to only that which is necessary to keep the stage at New Orleans below the danger point. The location of this floodway at Bonnet Carré on the east side of the river and the use of Lake Pontchartrain for the disposal of the excess water is the most satisfactory solution of this part of the problem. This floodway will be used about once in five years and its maximum flow will be only 20 per cent of the total Mississippi discharge at this latitude. The discoloration, due to muddy Mississippi water entering Lake Pontchartrain may sometimes extend out into Mississippi Sound when the floodway is being used, but the deposit of silt will be very slight. If all the silt should be dropped within 10 miles of the entry into the lake it would not exceed an average silting of 1/4 of an inch in depth or 1/32 of an inch per year, if distributed over the entire lake bottom.

In order to preclude the main river channel, between the mouth of the Red River and the Bonnet Carré spillway, from receiving more water than it can carry, the "Adopted Project" provides also for leaving the Atchafalaya Valley as it exists—a floodway, for excess water, from the back water area at the mouth of the Red into the Gulf of Mexico. The head of this floodway is now a fuse-plug levee whose operation will be automatic and similar to that of the fuse-plug levee at the head of the Boeuf floodway. Back levees will be constructed on both sides of the Atchafalaya Basin to limit the width overflowed. The existing levees on the Red and Mississippi Rivers will be strengthened and their heights raised. The Atchafalaya natural floodway will not function except during the extraordinary floods. The necessity for this floodway will perhaps occur on an average of not more often than once in 15 years. Its area is eighty per cent swamp and timber land which will be urdamaged by flood waters. The adjusted levees of the Mississippi and its tributaries in this section of the valley, together with the operation of the Bonnet Carré spillway, supplemented by the natural Atchafalaya floodway will provide adequate discharge capacity for the flood waters and effective protection for the population and its property.

The protection provided by the "Adopted Project" may be summarized as follows:

The area of the alluvial valley which would be flooded by the Mississippi River if man did not confine the flood waters is approximately 30,000 square miles. The flood control works to be constructed will fully protect over 20,000 square miles, including all of the towns and cities on the natural flood plain of the river. Of the remainder, approximately 9,450 square miles, comprising the land of the floodways and back water areas, which will receive partial protection varying from an average of two years in three to fourteen years in fifteen, depending upon the location, only 3,340 square miles is cleared land. The infrequent wetting of these limited areas, located in the natural overflow channels, is necessary for the safeguarding of the maximum property value and is economically justified by the total, complete and partial protection provided.

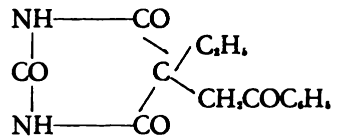
The flood control works briefly enumerated are: adjustment of levee heights, cross sections and locations throughout the alluvial valley; the river bank floodway on the west side of the river from Cairo to New Madrid; the Boeuf floodway; the Atchafalaya floodway; the Bonnet Carre spillway and floodway; and, general bank revetment and channel stabilization. The engineering plan is sound; the excess flood water is disposed of through the natural channels and contained in the natural back water storage areas which nature intended the Mississippi River to use for this purpose. This engineering plan of the "Adopted Project" was accepted only after a careful consideration of all other suggested schemes of flood control, and is the most logical, fair, straightforward and economically justifiable plan which will reasonably and effectively control the Mississippi River in flood.

THE ORGANIC CHEMIST AIDS MEDICINE

(Continued from Page 16)

ill effects, it is very desirable to improve on it, if possible. Changes which involved substituting other atoms, or groups of atoms, in place of the hydrogen atoms which are attached to nitrogen, were found to be generally destructive of desirable physiological action; but some of the changes involving substitution of other groups of atoms in place of the C_2H_5 groups, were found to be of value, and a number are in use. However, the perfect one is still to be found, and the further modification of the molecule is the subject of extensive research.

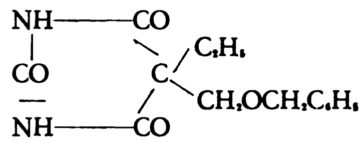
A chemist reasons somewhat as follows:—the CO group is a desirable group for hypnotics; veronal possesses three such groups; the addition of another such group should increase its effectiveness. Consequently the substance having the formula



is made, but found NOT to be anywhere nearly as valuable as veronal. Or again, benzyl alcohol is a local anaesthetic, and ether is a general anaesthetic. The formulas of these compounds are respectively

$$C_6H_5CH_2OH \text{ and } H_5C_2OC_2H_5.$$

A chemical compound, which is essentially a combination of these two types of substances with veronal, might be useful. Such a compound, formula



is produced and found to have properties which very nearly result in the death of some anmials on which the tests are made. But the work goes on, and even when the chemist is unsuccessful in giving to the world a new and better drug, he is clearing the way for the discovery of the drug in the future.

While the knowledge of groups and their position in a molecule, is still very useful in suggesting lines of research, it can be seen that the only way of knowing just what the effect of a compound on the human body is going to be, is to make tests, first, on animals and then, after it is known to be safe, on man.

Much more has been accomplished by the organic chemist in the production of drugs than is mentioned in this paper, but what has been done is only a small fraction of what remains to be done. And it should never be forgotten that advances in medicine are, of necessity, the fruit of united effort. The chemist alone could not go far; his work must be supplemented by that of the biologist, the pharmacologist, the medical practitioner and others. The hope held out to suffering humanity from such co-operative research is very great.

ELECTRICAL ENGINEERING EXHIBITION

(Continued from Page 7)

the light this current changes and the tube can be made a control device for many purposes. The Knowles tube is a glow tube, capacity controlled, which also has a wide field of application as a sensitive relay. In the demonstration, bringing a hand close to a large silvered ball caused capacity changes affecting a Knowles tube and illuminating an incandescent lamp.

The Thyratron, due principally to the researches of Dr. A. W. Hull, 1905, is an electrostatically controlled mercury arc tube having varied uses as a power relay of large capacity and is capable of handling directly relatively heavy currents. A low pressure of mercury vapor is maintained within the bulb, and the establishment of an arc between cathode and anode, over which current is passed to a load, depends upon the combined influence of grid and anode potential. For a given anode potential there is a definite critical grid potential which determines the time of starting the arc. Once established, the arc is unaffected by the grid; it can only be extinguished by removing the anode potential. By impressing an alternating voltage on both anode and grid and varying the phase angle between them an extremely nice control of average current is obtained by controlling the average time of flow rather than controlling by resistance the average magnitude. In this manner the greater part of the losses involved in rheostatic control of current are eliminated.

A very valuable historic exhibit was a model of the first commercial telephone exchange in the world, established in New Haven fifty-two years ago. This interesting switchboard with its talk-and-listen instruments, clumsy switches and call annunciator, was in working order and many in curiosity tested its operation. Ordinarily one's colleague drowned out his own efforts attempting to shout sufficiently loud to make himself

heard through the second instrument. Close by was a complete demonstration unit of dial telephone exchange equipment; the apparatus was under glass and the operation of the dial and selector relays was clearly visible. The contrast due to barely fifty years of development was striking.

An engine cylinder temperature indicator employing a thermocouple and milliammeter with its scale engraved in degrees of temperature was shown.

The problem of remote control and remote indication has been attacked on mechanical, mechanical-electric and hydraulic bases. None of these has been entirely satisfactory except over short distances. The problem is solved electrically by a device known as the Selsyn motor, a demonstration unit of which was displayed. The system consists essentially of two small three phase synchronous motors with three phase windings on the stators connected in parallel and single phase windings on the rotors connected in parallel and to a source of single phase alternating current. When the rotor of one is turned, current reactions are set up producing torque upon the second rotor and causing it to assume a position of equilibrium in exact angular coincidence with the position of the first rotor. These instruments are exceedingly rugged, simple and of great accuracy.

An exhibit that attracted probably the greatest attention was a voice-controlled electric model train which started, stopped and reversed at the word of the operator, speaking into an ordinary telephone transmitter. The control was through a vacuum tube amplifier and impulse selector relay similar to the type employed in automatic telephone switching. A definite number of voice impulses placed the selector finger upon a contact which completed a circuit to cause a definite response from the engine.

A 7.5 watt short wave radio transmitter, manned by licensed operators, was installed in the laboratory and messages were sent to all parts of the world via the American Radio Relay League.

PERSONALITIES

(Continued from Page 25)

poise and judicial temperament and served admirably to balance our engineering organization. (The head of engineering activities was a mechanical genius, but impulsive and erratic.) Later as Chief Engineer he rendered valuable service in refining and consolidating previous advances in the art, as well as making substantial contributions of his own."

Professor Dudley has taken an active part in transportation engineering as a member of Yale's committee on this subject and in cooperation with the Society for the Promotion of Engineering Education, the Railroad Division of the A. S. M. E. and the executives and educational directors of the railroads and the railroad supply industries.

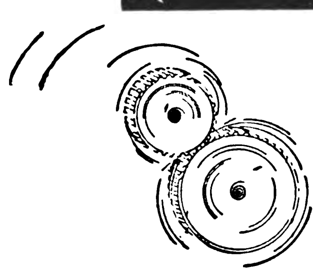
At the Summer School for Teachers of Mechanical Engineering at Purdue last July he presented a paper which was one of the very few selected for publication. A professor who was at the Summer School remarked, "Dudley is wholesome minded. He has seen enough and is big enough to be broad minded; he does not push some detail that he likes and he does not see his own personal interest all the time."

Professor Dudley has been a member for five years of the Meetings and Program Committee of the American Society of Mechanical Engineers, during the past year its Chairman. The committee had a leading part in arranging the Fiftieth Anniversary celebration of the society, an exceptionally notable event. Dudley was later made Chairman of the Executive Committee of the Anniversary.

When his connection with the Meetings and Program Committee terminated last December there was a Testimonial Dinner at which letters from the members were presented.

"Your five years of service with this group have endeared you to its members in a deep and abiding way. You have invariably stabilized our discussions, and your broad and kindly attitude toward every question has sweetened our decisions. It is because of the unusual qualities of judgment, fairness and good will which you have so happily combined, that we shall miss you more than you can realize; but at the same time we want to express our sense of gratitude and satisfaction for the opportunity which these years have given us on the Committee, of association with you.

"Your outstanding attribute has been that of modesty. With all of your accomplishments as a member of the faculty of a distinguished university, whose foundations are those of our country, you have unfailingly shown a viewpoint which has been characterized by delicacy and decorum. Your noteworthy industrial experience as Chief Engineer of one of our largest manufacturing companies has given to your academic viewpoint an unusual clarity and practicability."



AMERICA

TRAVELS IN HIGH

THE 1930 SENIOR INSPECTION TRIP

(Continued from Page 33)

Saturday, March 29, was entirely spent at the Westinghouse plant in East Pittsburgh. One engineering development noted here was the substitution of welding for foundry work in the manufacture of motor frames and other parts. A luncheon was given the Yale students by the Westinghouse Company, at which many company officials and Yale alumni were present. Prof. Scott was warmly greeted by some of his old associates, and an enjoyable program of talks was brought to a close by an entertaining demonstration of certain research developments.

The electrical engineers left Pittsburgh Saturday night for Niagara Falls, where they were free Sunday, and spent the next two days in inspection of American and Canadian power plants using the splendid head and volume of water available for the generation of electrical power. Nearby industries, such as the Carborundum Company, the Kimberly Clark Paper Company, and the Shredded Wheat Company making use of the cheap power available, were visited.

Wednesday, April 2, the electrical engineers went through the mammoth Schenectady Works of the General Electric Company, and after this visit their spring vacation began.

Meanwhile the industrial and mechanical engineers had gone by train to Akron, Ohio, Sunday morning. There they were luncheon guests of the Goodyear Company at the University Club, and were taken by bus to the airship dock in which the Goodyear Zeppelin Corporation is building the ZRS4, an airship which is to be the largest in the world. A feature of this ship will be the placing of the engines inside the hull.

From the airship dock the party went by bus to Wingfoot Lake to see two Goodyear blimps, then to the Portage Country Club, where a dinner provided by the Firestone Tire Company was enjoyed with members of the Yale Club of Akron. After the dinner moving pictures of Firestone plantations in Africa were shown.

Leaving Akron by sleeper, Detroit was reached early Monday morning, and the day spent at the Ford plant at River Rouge. Here neatness and cleanliness was the rule, but the mechanical conveyors, the mass production methods, and the activity of the workers were the striking features. The party was given lunch by the Ford Motor Company.

A second day in Detroit started with a visit to the Ford airplane factory, where a large plane being equipped with three Packard diesels was the object of considerable interest. The Ford airport was inspected, then a short stop was made at Ford's historical village, where Edison's old Menlo Park laboratory is reproduced. The afternoon was spent at the Packard Motor Car Company's plant, where the large scale production of quality cars was seen, and the Yale Seniors had the honor to be the first group shown through the new Packard diesel factory.

The last day of the trip was spent in Dayton, Ohio. Here the Thomas and Hochwalt Laboratories showed the work of a research organization, and the Frigidaire assembly plant proved a fine example of modern manufacturing methods. The Frigidaire Company has one of the largest one-story factory buildings in the world. After lunch at the Frigidaire plant, buses took the group to Wilbur Wright field of the Army Air Corps. Many types of planes were seen, and the development work being done was explained by guides. When the visit at Wright field ended, the trip was over.

THE MECHANICAL ENGINEERING EXHIBITION

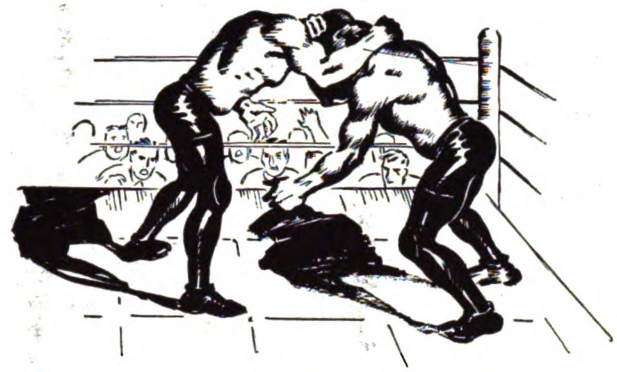
(Continued from Page 6)

appreciated. It consists of a small generator coupled to a gasoline engine similar to an outboard motor for a boat.

Among the other exhibits were the regular engines of the laboratory—the Chrysler "80" engine, the one cylinder Mianus Diesel engine, the Otto gas engine, the Sullivan air compressor, the Terry Turbine, and the Skinner uniflow steam engine. All these engines were running during the exhibition and were very ably explained by the men in charge of them. Two very interesting tests which were run in connection with the exhibition and which got less attention than they deserved were the test on the Jahns steam engine governor run in conjunction with a Reeves variable speed transmission and the tests on house heating boilers using oil burners. The latter test was run by Mr. Tavanlar through the courtesy of the Society of Heating and Ventilating Engineers and thse American Oil Burner Association. Tests were also run on the laboratory's fan and wind box and air blower. The object of these tests was to determine the relative efficiencies of various orifices at various blower speeds. Through the courtesy of the C. S. Mersick Company a large collection of standard Boston Gears and reduction units was on display during the whole time of the exhibition. On the second floor, the Westinghouse air brake system and the models of applied mechanics interested those who could get by the door of the lecture room, where movies were in progress, without going in.

Moving pictures of various engineering subjects in the fields of both electrical and mechanical engineering were shown continuously during the hours of the exhibition. These films were loaned through the courtesy of various industries.

BULK MATERIAL



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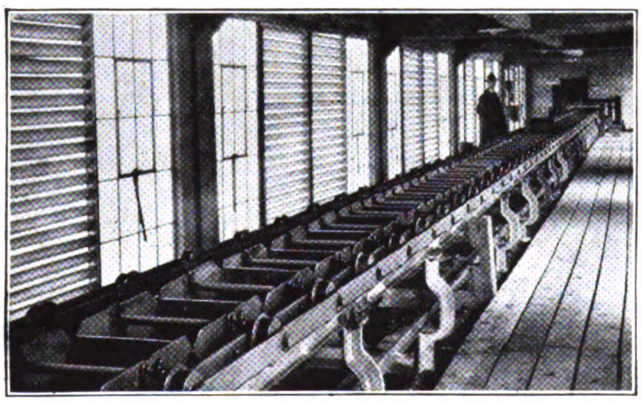
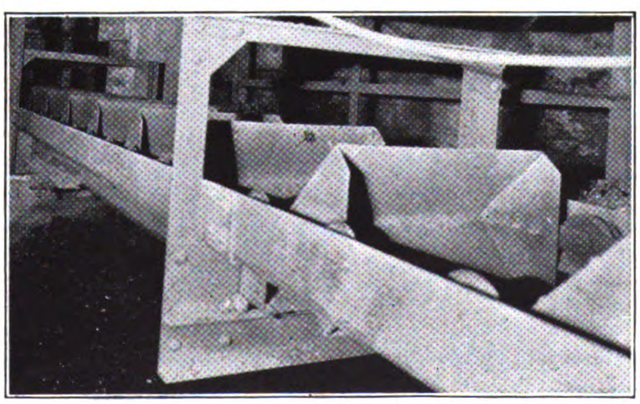
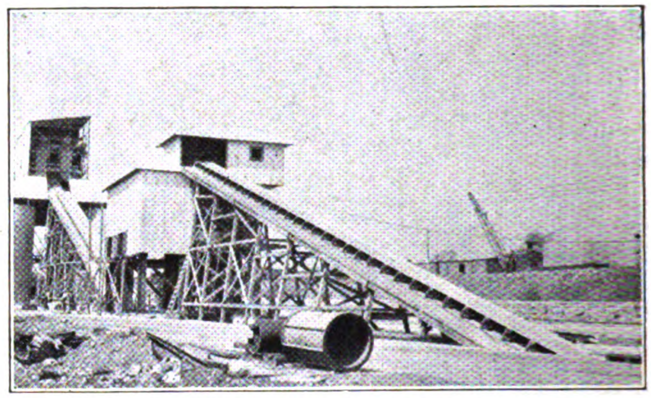


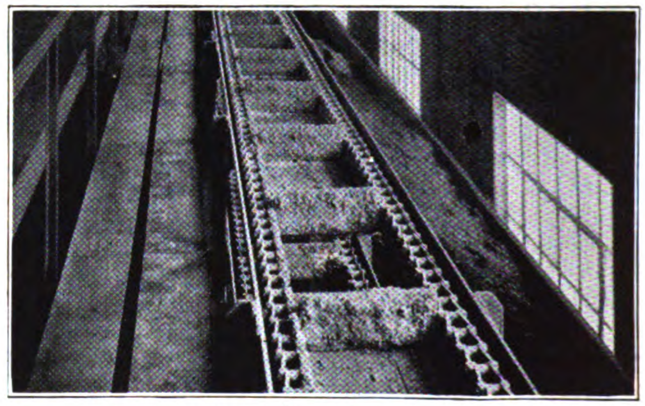
A Rex Pivoted Bucket Carrier for handling coal



A Rex V-Bucket Conveyor



A Rex Belt Conveyor for handling rock



A Rex Scraper Conveyor

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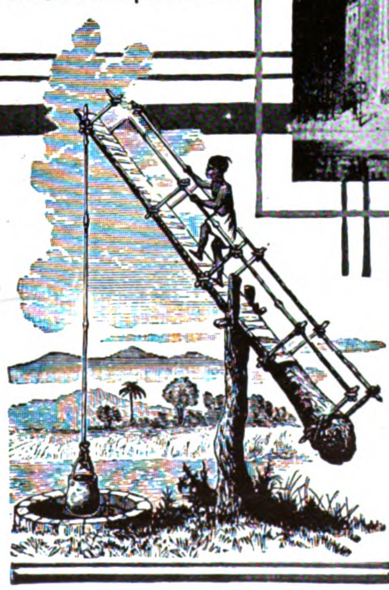

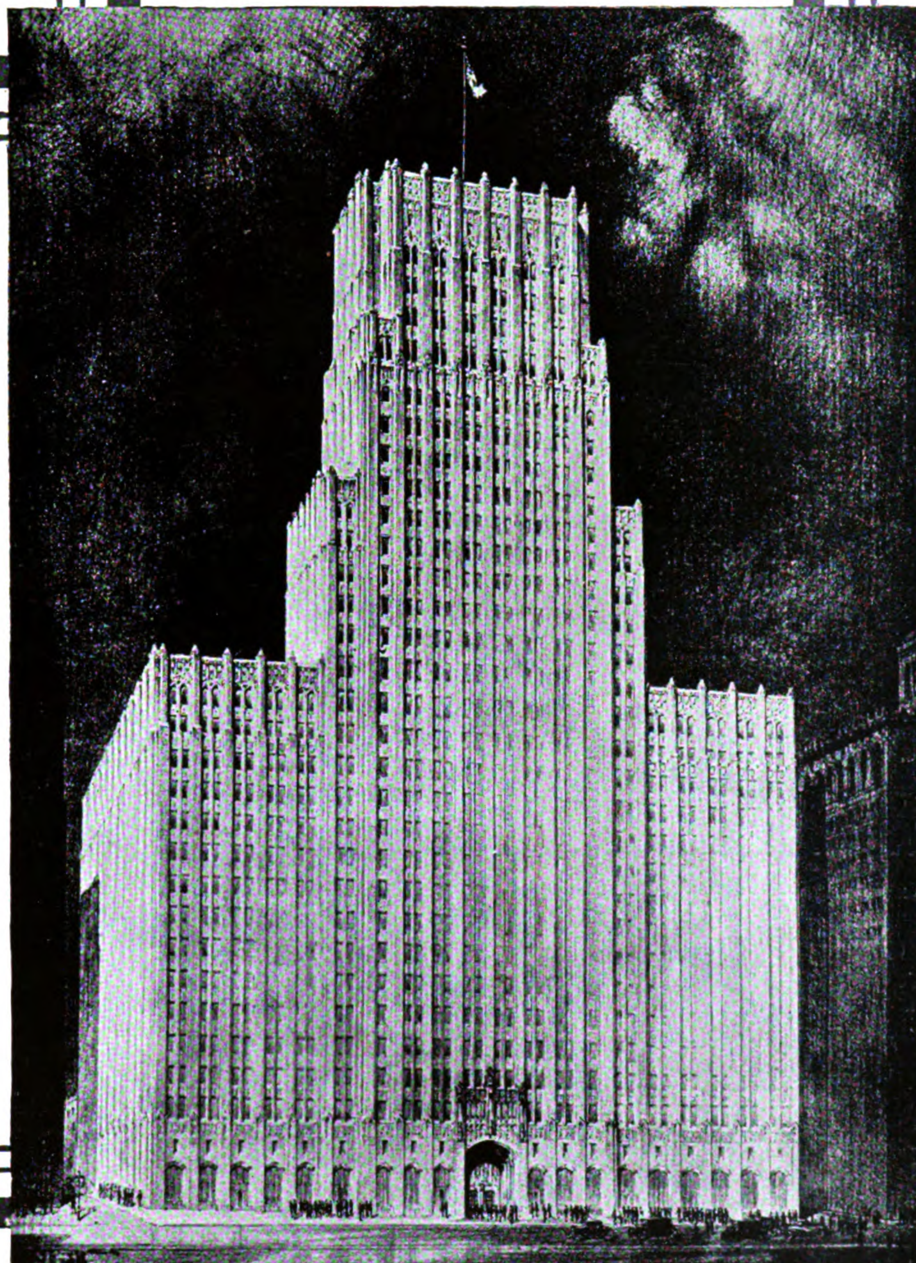

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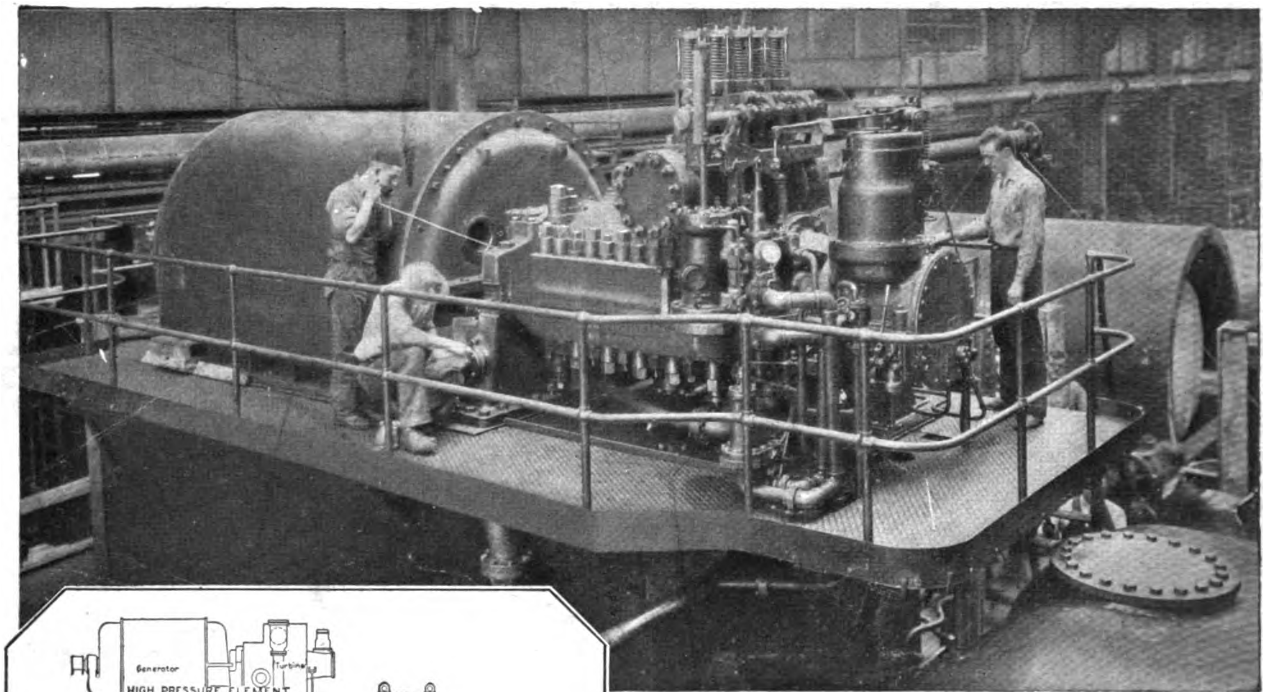

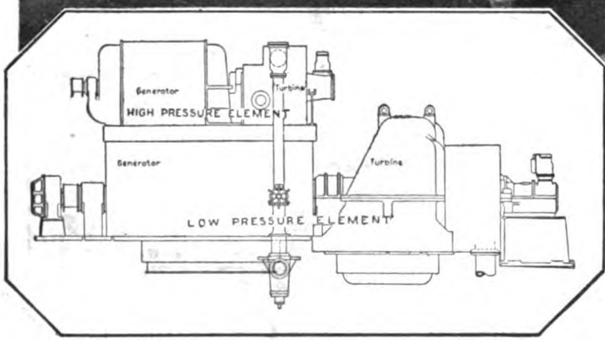

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